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LIGHT • HEAT • POWER • BYE-PRODUCTS

[Founded in 1849 as the "Journal of Gas Lighting."]

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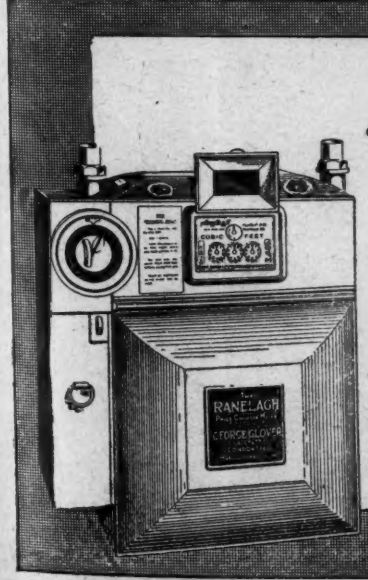

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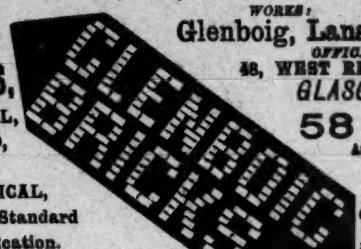

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VOL. CLXX., No. 3240.] WEDNESDAY, JUNE 17, 1925. [77TH YEAR.

EDITORIAL NOTES.

The Institution Meeting.

As we glance over the doings of last week, at the annual meeting of the Institution and in conjunction with it, it must first be said that it was a brilliant success. Such a success is not due to a single feature, but to many—ranging from presidential energy and admirable direction, numerical representation, sustained interest through the quality and current appropriateness of the topics before the members, to the attendant attractions, and the contribution of exquisite weather. Those who were participants found all these traits; and the mainspring throughout was the President (Mr. J. Ferguson Bell, M.Inst.C.E.), whose zeal in seeking to maintain the best traditions of his office and his loyalty to the interests of the industry so attracted the attentions of Old Sol that his enthusiasm was almost unbounded. Everybody concerned in the meeting is grateful to the President and his great luminous ally. It was a happy and profitable week, with no blank spaces in it. It brought home to us the great expanse of the interests of the industry, of the universality of its work, and of how through efficient organization we are causing other people to become more and more interested in our affairs. This last-mentioned aspect shows a trend in the right direction; and every means and opportunity should be taken to cultivate it. The industry has been all too content to live and to serve and have no associates beyond its own boundaries. This is a mistake; the present proves it with influences at work in high places which are not to the advantage of the industry. But the mending or changing of this deficiency is now in process of development; and our claims and far-reaching importance in the system of affairs and service are becoming better known. There is much to be done and to be maintained in this direction. Fortunately the industry is in the guiding hands of those who fully realize this, and are working to make new friendships where they are wanted—not for the purpose of gaining any undue consideration, but to ensure that knowledge of us is what it should be. At the meeting last week, there were men from the political world. On one occasion the President and Council of the Institution had the pleasure of entertaining one of His Majesty's Ministers (the President of the Board of Trade), and an ex-Minister and leader in the Labour Party (the Right Hon. J. H. Thomas), while at another stage in the proceedings the Right Hon. Sir Alfred Mond, Bart., addressed the members. This is as things should be. We want, too, to encourage inter-relationships abroad. We have both technical and commercial interests to serve; and a better knowledge of us by our friends and by us of our friends and of each other's work and advances will be mutually helpful. On this occasion members of the profession from the Continent and from far overseas came to, and took part in, the meeting. The President of the Société Technique du Gaz, through M. Baril, contributed an item of large interest on the subject of tankless gasholders, which, with the discussion, has assisted considerably in clearing away or thinning down doubts regarding these structures.

In the succeeding article, comment is made upon the Presidential Address, and preceding the General Report there is a review of the entire proceedings. There are certain of the reports and papers upon which comment may be deferred. The members were gratified with the excellent report made by the Education Scheme Committee, which was presented by Mr. F. W. Goodenough. For such an innovation as this scheme, it shows excellent progress, considering these are early days in its career. It is making history, because what is being done is going to be of untold advantage to the industry in equipping it with men specially trained for its service and responsibilities. Good work has been done for a number of years by the Gas Investigation Committee, through the researches carried out under the direction and supervision of Prof. Cobb at the Leeds University; but the past year has been largely occupied in preliminary work on the Corbet-Woodall memorial experimental plant, which we confidently predict is going to be invaluable in increasing the scope of research. The Gas Investigation Committee would, Mr. Thomas Glover says, be pleased to receive for consideration suggestions as to work which should be taken in hand. One is a thorough research into coke production. We can think of no line of investigation which would be at the present time of greater service to the industry; and the sooner it is taken in hand the better. From the references to coke in one of the reports, we think that Prof. Cobb and his staff have this in mind. There is much need for precise information as to the physical qualities of coke which, without sacrificing our high temperatures in carbonization, will give good ignition and combustible virtues to the product. Having obtained this information, the industry requires to know the blends of coal and other conditions which will best yield such coke. There is also the questions of mixing a proportion of coke with coal charges, and the definite ascertaining of the effect this would have upon the transmission of heat through a charge, upon the throughput and productivity per retort, and upon the ability to use lower temperatures with advantage to the life of the refractory materials of which retorts and settings are composed. There is a connection here between the hoped-for investigation at Leeds and the Joint Refractories Research Committee's work. As Sir Arthur Duckham said, if we can get a carbonizing plant to have a longer life, the costs of carbonizing will be reduced considerably; and this will materially affect the net cost of gas. The Wrought-Iron Tubing Committee, under the chairmanship of Mr. Albert Stokes, have quickly got well into their work; and it is easy to predict a valuable result in the shape of a specification and test. The engineering and other papers—to which reference will be made as opportunity permits—by Sir Dugald Clerk, Prof. C. V. Boys, Mr. W. M. Carr, and Mr. George Evetts were in several respects of first-class importance.

Hearty congratulations and good wishes are offered to the new President (Mr. C. F. Botley, of Hastings), and to Mr. John Wilkinson and Mr. H. D. Madden upon their advancement along the road to the Chair of the Institution. The great enjoyment which the President and Mrs. Bell gave the members on Tuesday night will long be remembered. The intellectual treats provided for the members by the Gas Light and Coke Company, the South Metropolitan Gas Company, and the National Physical Laboratory were highly appreciated. And as to the excursion on Friday, it was the happiness of the Chairman (Mr.

W. Woolley) and his colleagues of the Derby Gas Company to know how fitly it crowned and finished a glorious week. Never has there been an Institution meeting which has exceeded, though some have equalled, the success of this one. During it, the interests of the industry have been distinctly advanced.

The President on Our Opportunities and Requisite Work.

Perspicacity and lucid statement were characteristics of the Presidential Address; and there was a continuity of thought through it which carried us from basic facts as to the position and importance of the industry in the work and economics of the times on to our duty in making the maximum use of our potentialities by insistent, persevering research and by the application of the findings as we proceed, and as opportunity serves. There is good ground for such counsel. We realize that there is a strong movement which if successful would—providing the expectations were fulfilled—place in the hands of our competitors advantages which it is not proposed to confer upon the gas industry; and, truth to tell, we would rather be without them. But that movement should be a blessing in disguise in urging us to do everything possible to strengthen our hands for the more acute competition which threatens. For our own part (while doing all possible to further resistance to the proposals of the Government in regard to the electricity supply industry as being unjust if national money is used for helping one competing industry as against another, and as showing no national advantage—indeed, the reverse in respect of the utilization of our coal resources), we have confidence that the gas industry possesses such vitality and possibilities if developed with set purpose that the situation in those spheres in which gas supply has proved advantages will be, so far as electricity supply is concerned, considerably worsened. That confidence is reinforced by the address of Mr. Bell, which shows conclusively that, if the Government are going to render financial assistance to the electricity industry, they are not only backing the wrong horse, but they are doing something that is wrong nationally and in principle.

The address shows, as does every part of the proceedings at the annual meeting, the largely increased strength of the industry through the developments of recent years. Those developments have given us new foundations. The problems of to-day are far greater than those of yesterday; and each development produces fresh problems. Right in the forefront of the address, the President solicits the continued enthusiastic activity of members in promoting the advancement of the industry by applying themselves to the solution of the many problems on which success depends. In other words, what he urges us to do is to use our existing strength, and leave nothing undone, in the way of research and education, to develop the industry's resources so that we may maintain our supremacy, despite any political errors that may be made. We place on equal planes both research and the education of men for the industry. The two are united and interactive; and, holding that view, we welcome the foreshadowing in the address of the probability that membership of the Institution will in the near future be by examination. If that comes to pass, knowledge being the dominant essential for membership, we see no reason why there should be any limitations of an official order placed upon membership, though in the first stages, at any rate, we do see reasons for examinations being graded in respect of men managing works of the lower magnitude. It is the expansion of our industry, its services, and the enlargement of our outlook, together with the more active competition through the development of the resources of our competitors, which makes more forceful the constant reminder of the need and importance of research and adequate and specialized educational training.

The President gives statistics showing the progress of gas supply in this country and America. The comparison which this affords is extremely interesting. Our progress in this country, with an investigation of the lines along which it has been made, is directive as to the future. We have reached a consumption of gas in statutory supply areas, taking the latest available data, of 282 thousand million cubic feet a year, with about 8½ million consumers. But in America (despite the constant references of our electrical friends to the wonderful accomplishments of electricity in the States), they had in 1923 a consumption of 370 thousand million c.ft. of manufactured gas, and 760 thousand million c.ft. of natural gas (together 1130 thousand million c.ft.) with 9½ million consumers—that is to say, only a million consumers more than we had, but a consumption which dwarfs ours completely. And in view of the higher calorific values of manufactured gas in the States and the high calorific value of the natural gas, the thermal disparity is much greater. In America, as here, large strides are being made in the applications of gas for domestic heating apparatus, cookers, water heating, and gas-fires; but it is to industrial work that a large proportion of the huge consumption of both manufactured and natural gas is applied. The availability of natural gas in the States taught industry there the value of gaseous heating; and now that there is a dwindling of the yields of that gas, the manufacturers are anxiously looking round for ways and means of producing not only the necessary compensation, but more gas. And the prospect is that it will be done by the gasification at the collieries of low-grade fuel, with transmission through the natural gas systems—perhaps at first in conjunction with the natural brand. The fact that the natural gas is giving out in some districts indicates what will happen in others; and we therefore look for a prodigious increase in manufactured gas in the States for industrial purposes. In this country we have not had the advantage of natural gas supplying thermal energy at low prices; and the education of our manufacturers as to the advantages of furnace heating, steam raising, and other processes by gas has consequently been a slower process. Now the British Commercial Gas Association have on record a list of more than 4000 trades in which gas is used with an average of seven processes in each. This, as the President says, indicates the immense field there is for future development and enterprise. Within its limits, Derby illustrates what a studied consideration of the industrial business can achieve; but we are bound to say that Mr. Bell, pleased as he must be with what has been accomplished there, will not be satisfied until a still greater proportion of the growing output is for industrial purposes. In the past decade there has been an increase in the industrial load at Derby of 128 p.ct.; the total industrial consumption last year being 326 million c.ft., or 21 p.ct. of the total output. There gas-engines have for over twenty years been fixed on hire-purchase terms, and now the progressive Board have decided to let them out on simple hire. We admire the enterprise and the results.

The fact of the matter is that the gas industry in this country, proud as it is of its achievements, is only just awaking to its great potentialities; and thus it is that energy has to be directed to ascertain how best to meet the requirements that have opened up before us—domestic and industrial. When we survey, as the President leads us to do, the enormous field there is in domestic heating in several directions, and the untold scope there is in industry for our primary commodity, there is satisfaction. But satisfaction alone will not help along the development which will suppress the waste that is going on to-day through the immolation on the altar of crudeness of a vast tonnage of coal annually—representing a loss, the President calculates, of £30,000,000 a year— nor will it without work in other directions teach the manufacturer the economic advantages of gas heating through the employment of such a flexible and tractable fuel as gas. As the President shows, electricity cannot offer such value for money as gas for any ordinary heating purpose. The efficiencies he gives for gas are easily upheld in daily practice; and our electrical friends cannot dispute the fairness of those he supplies for electricity, for the simple reason that they are determinations from actual tests. Then, further, the industry has the liberty conferred by the Gas Regulation Act of adopting the most economic calorific value for gas in relation to local circumstances. That liberty we must not forego, because we do not know what the future has in store. On that point, the President thinks there is much to be said for a uniform calorific standard of (say) 500 B.Th.U. for the whole country.

That is a view—we think the only one in the address—in which we disagree with the President. We do not think a universal calorific value would do much to reduce manufacturers' costs, seeing that the difference between one calorific value and another (within the limits of practice to-day), taking into account too the difference of pressure and specific gravity, is more a matter of adjustment than of structural variation. It is true that 500 B.Th.U. would simplify the work of the clerical department, and enable consumers readily to convert volume into therms. It is true too that there has been a marked tendency on current economic grounds to return from lower declared values to 500 B.Th.U. or something approaching. But do not let us talk of what would be the reactionary step of restoring uniform value. In view of the unknown future, the flexibility gained by the Act must be maintained; and the address supplies other reasons why it should be, and why gas making in this country should not be again stereotyped. The President gives representative thermal efficiencies for the various gas-making systems; but he himself points out that those efficiencies are subject to the variations that availability of different grades of coal brings about, and which necessitates the placing of economic efficiency as shown by the net cost per therm into the holder before the thermal efficiency of the process, important as this is in securing the maximum result from the process in the circumstances of its use. There we have a reason, even in current conditions, against returning to a uniform calorific value throughout the country. Our processes, too, may undergo considerable changes before long, by, for example, altering the characteristics of retort charges to secure more rapid heat transmission, and better physical qualities in coke. That may hasten the adoption of internal heating and the displacement of current practices. The President says we are on the eve of great developments in the utilization of gas; and it is fortunate to be able to believe that we have not reached the end of important developments in our carbonizing operations. Moreover—and the President makes a strong point of this—investigations in America with natural gas of 1100 B.Th.U. per c.ft. and manufactured gas of from 725 to 500 B.Th.U., and the work of the Research Committee of the Institution and the Leeds University with gas between 500 and 240 B.Th.U., "indicate that the relative usefulness of various gases for ordinary purposes is directly proportional to their heating value, and that there is no advantage in gas of the lower heating values, but rather the reverse for gases of low calorific value with high inert content." The opposite lesson is also indicated—that there is no advantage (other than in the volume of gas to be distributed) in the higher heating values compared with the lower ones, provided the inert content is not abnormal, and there is consistency in the gas and conditions of supply. On all material points the evidence shows the wisdom of not giving up, by voluntarily returning to uniformity of calorific value throughout the country, the liberty conferred upon the industry by the Act. Under it every individual who agrees with a 500 B.Th.U. standard in his current circumstances can adopt it.

However, this all shows that the address points to the immense scope for service that lies before the industry; it indicates the directions of greatest possible development; there is the liberty conferred by the Gas Regulation Act; there is the important fact that we can through that liberty alter our practices to suit changing and uncontrollable economic conditions; and there is the fact that in use the efficiencies of gases of different calorific values are approximately the same. In those conditions there is plenty of inducement and encouragement to search and to work for still greater progress in our manufacturing systems. At the moment we appear to have got to a point where the over-all efficiencies of various processes do not show any notable variation; and though some processes give more gas and less residual products than others, the net cost per therm into the holder (combined with other considerations) has not been sufficiently seductive to induce gas engineers to make those systems their main sources of supply, but, save in restricted circumstances, they have continued to occupy the positions of auxiliaries. While talking of this matter, we must congratulate the President regarding his statement as to net cost of gas last year into the holders at the Litchurch Works of the Derby Gas Company. Carbonizing cheaper coals and smalls, the over-all thermal efficiency was for a mixed gas 70·86 p.ct.; and the average cost for coal, coke, and oil was 4·48d., and less residuals 3·34d., or 1·14d. net per therm for a gas of 503·8 B.Th.U. The oil used was only 0·0428 gallon per 1000 c.ft. to enable the use of larger percentages of C.W.G. to meet sudden increases in the demand. Of a total make of 1362⅛ million c.ft., 20·93 p.ct. was blue or slightly carburetted water gas. In this connection, the President emphasizes the invaluable aid that the auxiliary types of plant are to the gas manufacturer, both in promoting as occasion demands better economic conditions, and in meeting peak loads or needs in times of emergency.

This brings us back to the insistent note which we find in the address as to utilizing in every possible way the services of research, to point the directions in which we can, with still better effect, enter into the vast open territories that lie before the industry. Research is the most direct course to development. The President, as an old gas practitioner, knows it; and he cannot give too much praise to the work that has been done by the Research Committee of the Institution and the Leeds University, and by the Fuel Research Board. They have supplied knowledge which has removed defects, and pointed the ways to a greater certainty of result. They have also shown present limitations, and the advantages to progress that we possess in the efficiencies of utilization of our heating product. We have reached a state of knowledge at which it may be said that with present plant and materials we are getting approximately maximum results where there is careful supervision and control. Let us, however, regard that in looking to the future as all fundamental. What is there beyond? Research and time alone can inform us. It is to that the Presidential Address leads us. And if we merely direct the attention of readers to the sapient views of Mr. Bell on the subject of working to enlarge the field of coke utilization, and to his protest against Government assistance to the electricity industry, and his plea for an inquiry covering a larger field than electrical power, it is because the matters already dealt with provide the main theme in an address which gives us abundant reason for pushing forward in the attempt to gain more and more strength and power for meeting the demands that lie before.

Bitumen and Electricity.

NATURALLY, with a large assembly in London last week of those chiefly executively responsible for the technical and commercial interests of the gas industry, a great deal has been heard of the matters upon which the industry is in unison acting on the defensive. The present position is that the use of gas is increasing in volume, especially for domestic heating and industrial purposes. The Government, on the other hand, are proposing to "assist" the electricity industry to co-ordinate its generating procedure and to expand its means of distribution. Why the Government should do this, and not leave it to the industry itself, is not at all clear, either on rational or national grounds. The secondary products of coal carbonization have suffered a set-back; and yet Sir Henry Maybury, who began the ride to his present distinguished position over tar-surfaced roads, is now—according to newspaper reports—decrying his best friend tar for the purpose of road work, and advocating imported bitumen in preference to the home-produced material. Many people who know fully the long history and the acclaimed and acknowledged advantages of tar for road purposes, originally demonstrated on the roads of Kent when Sir Henry had charge of them, are asking why there is this change of front; and they are getting inquisitive. Coke, also, is not yielding as it should do; and among a combination of several causes which has produced the set-back, is the one that the coke-oven industry is increasing its energies in producing coke suitable for purposes for which gas coke is employed. There is sulphate of ammonia, too, which has now to meet the condition of increased output through the enormous supplement of

synthetic nitrogen. But the new competition that has to be faced by the two latter secondary products is of an order which must be combatted by the exercise of ingenuity and energy within the gas industry itself. In regard to coke, we have the advantages of local situation and better distribution facilities than the coke-oven people; and it is a question of adding to that a proper preparation of coke and improving the quality as far as possible, with the view of making it not only as acceptable, but preferable in the region of its production.

The questions of tar and bitumen and electricity are altogether different ones. It is not a matter of improvement in the quality of our products or trading methods; it is, to put it bluntly, a question of dealing with influences in high places. Last week there was much private discussion among gas men as to the lately developed advocacy of bitumen in place of prepared tar for road work; and the matter is not going to be allowed to rest where it is. The Government are busy, under the Safeguarding of Industries Act, protecting various industries. Some of the Labour members—strong anti-protectionists that they are according to party creed—are beginning to talk of the productions of our own workers being favoured instead of those of foreign workshops. Twenty of them voted for Imperial Preference last Friday; and there would have been more had they been in the House at the time. However, as to safeguarding our own industries and productions, there is great unemployment in the land; and our politicians are seeking ways of realizing relief from the financial burden and loss that this entails. The miners are seeking to improve their conditions. Tar is a commodity produced from coal in British works, by British workmen, plant, and capital; bitumen is an imported article. If he is reported correctly, Sir Henry Maybury is turning his back on British tar for British roads, and is recommending bitumen. It would be of interest to know whether there is any misunderstanding. In the presence of the President of the Board of Trade (Sir Philip Cunliffe-Lister), at a luncheon last week, Mr. D. Milne Watson stated that Sir Henry was reported to have said that tar would stick to anything except the road. To say this of a British product, and to attempt to persuade people to use imported bitumen for road-making purposes, Mr. Milne Watson emphatically described as a "scandal." If Sir Henry has not been misreported, then he has to explain to people who years ago admired and appreciated the roads of Kent, why it is that the tar stuck to the roads very well then, and why the Mr. Maybury of those days issued many laudatory reports concerning its advantages to the users of roads and its preservative qualities which were of benefit to those responsible for the upkeep of the surfaces—reports and papers such as the one before the International Roads Congress in Paris in 1908. [See "JOURNAL" for Oct. 27, 1908, p. 266.] The President of the Board of Trade knows the roads of Kent, and so do thousands of other people; and at the luncheon referred to, he put the question as to whether it is not a fact that the roads of Kent, which in past years set the standard for road construction throughout the country, did not obtain their pre-eminence by the use of tar, and not of bitumen. The reply came from Dr. Charles Carpenter that, when Sir Henry Maybury was an official of the county authority, and was responsible for the Kentish road system, tar was used as the surfacing material, and the roads were a model which should have been generally followed. Thousands upon thousands of the users of those roads can give similar testimony; and therefore it is fair to ask, Why this *volte-face* on the part of Sir Henry, who was the pioneer in this work? That is a question which sooner or later must be answered, as well as the one which will be put by those people who are disinterested in the materials used, but who are well acquainted with the roads of Kent and other counties, as to why years of good experience with tar have come to an end with the exploitation of imported bitumen for the same purpose. If it is a question of fisheries, then the roads alongside such rivers and streams are of comparatively short length compared with the enormous aggregate length of other roads; and tar can now be prepared (as the South Metropolitan Company are demonstrating at Wembley) so that washings from it are perfectly innocuous. There will be general agreement with Sir Philip Cunliffe-Lister that, having regard to the general state of trade, and the fact that industry is working on a diminishing margin of profit, it is of vital importance that use should be made for home requirements of commodities made in this country rather than of imported materials—due regard being had to the national interests involved. In the employment of any product of coal, Sir Philip also remarked, home industry is helped, and more money is provided to found new markets. What was actually said on the subject at the luncheon will be found reported elsewhere.

Tar and bitumen, however, were not the only topics privately and publicly discussed during the week. There were the Government's proposals as to electricity. On the opening day of the meeting, there was a deputation to the Ministry of Transport (headed by Mr. D. Milne Watson) representative of practically the whole of the company and municipal gas undertakings of the United Kingdom. The case of the gas industry as to the proposals was laid before Colonel Ashley, Sir Burton Chadwick, and Colonel Moore-Brabazon; and Colonel Ashley undertook to bear in mind the representations made to him, and to see that they had due consideration. If "due consideration" is given to them, the Government must see that there is no need for their intervention in the national interests; that any financial assistance to the electricity industry is unnecessary, and would, in any case, be unfair to a competing industry, which has developed itself by its own exertions and from its own resources; and that the problem in hand is one which should receive investigation from the source of power and heat—coal—in order that the error should not be made of giving Government support to any project which would mean a wasteful utilization of our principal natural and national asset. In his address at the meeting of the Institution, the President also made out a strong case against Government assistance to the electricity industry. The matter was again raised by Mr. Milne Watson at the luncheon at which Sir Philip Cunliffe-Lister was present. Sir Philip urged that the gas industry should not spoil their case by placing their claims too high, and suggested that, if there was some particular way in connection with an industry in which the Government could assist to bring about better conditions in the national interests, it was a matter for their consideration. We know that the Board of Trade have deeply at heart the interests of the gas industry. There is no question about that; but no one in the industry desires that the Board should make any move for preferential treatment to it, beyond enabling it, through its own resources, to provide the best possible public service. But we do submit, with all deference to Sir Philip, that it is not the gas industry that is placing claims too high, but (we judge from speeches by Ministers and statements in Parliament) it is the Government who are doing so through misconceptions and mistakes due to the want of fundamental, elementary, and comparative knowledge of this particular subject. The inquiries of successive Governments into this matter have been, *ab initio*, too narrow to place them in possession of that fundamental, elementary, and comparative knowledge which would have enabled them to arrive at right conclusions. There are men in the electricity supply industry who do not want Government assistance or interference; there are others who are laughing up their sleeves at the prospect of the Government—in sheer innocence—supplying "assistance" from the national funds to help to build-up an industry which is already enjoying a considerable measure of prosperity. If there is anything in the proposals of the Government which competent electrical men consider would be of advantage, does the Government think that, without having recourse to the moneys of the taxpayers, the electricity industry would not find ways and means of adopting them? The industry is not in an indigent condition. The truth lies in the contrary direction. If the Government require more evidence, it is at hand; and, in seeking it, the addresses which Mr. Milne Watson has recently delivered will be considerable enlightening aids.

The gas industry cannot afford to sit still while such questions as those to which we have referred are developing. It would be of little use to raise a protesting voice

after the mischief had been done. The members of the Government could properly say: "Why did you not speak before?" and they would be justified in ignoring an industry which had allowed things to proceed without taking defensive action. In both the matters of bitumen and electricity, the gas industry is fighting not only in its own interests, but in those of the nation. That it is doing so can be proved up to the hilt; and, if that is true (and we know it is), then the industry is not placing its claims any too high.

Chemical Manufacturers and the Gas Industry.

The chemical manufacturers have, through Mr. J. L. Deuchar, the Secretary of the Castner-Kellner Alkali Company, Ltd., pursued the Gas Light and Coke Company through the Courts right to the House of Lords, in connection with their manufacture of caustic soda for converting naphthalene into beta naphthol. The importance which the chemical manufacturers attached to the case is attested by their action in taking it to the House of Lords. The fact that in every Court the Gas Light and Coke Company won, is significant of the strength of their right. We congratulate them on the result of a case which was a deliberate attempt on the part of the chemical manufacturers further to control the liberties of the gas industry. In the dismissal of the appeal, the Lord Chancellor, and Lords Dunedin, Atkinson, Sumner, and Buckmaster were unanimous. The chemical manufacturers have—at a price—gained the knowledge that they cannot be permitted to rule the economies of another industry.

Gas Prohibition by Local Authorities.

We are pleased to note that a point we have previously raised—on a recent occasion in connection with the Newport (Mon.) Corporation Bill (*ante*, pp. 444, 719)—has also been receiving the attention of the National Gas Council. It is becoming a common practice for local authorities possessing electricity undertakings to insert in tenancy agreements, in respect of houses built by them as representing the ratepayers, a condition to the effect that gas shall not be used for specific purposes. The question has been discussed by the "N.G.C." as to the position that would arise should a tenant apply for a supply of gas, as he or she is entitled to do under the Gas Acts. Gas suppliers have no power to refuse, seeing that the law stands above conditions inserted in tenancy agreements by a municipal authority. Not long ago a local authority was prevented from supplying electricity to a house which had been wired by non-union labour, by a threat that, if they did so, the trade union employees at the generating station would be called out. An action by the tenant against the local authority resulted in a decision that they were bound to supply under the General Act. The "N.G.C." considers that the matter is of such importance to the whole industry that Counsel's opinion should be taken. It will be interesting to see the result.

The Coke Competition.

Papers for this world-wide competition are beginning to arrive. There is now less than a fortnight before the competition will close. Careful attention should be given by competitors to the conditions as to name and address being enclosed in a sealed envelope bearing outside the *nom de plume* which appears on the paper. Those contributors who are competing in different sections should send the contributions in separate envelopes. These requirements, with several others, were plainly set forth in the issue of the "JOURNAL" for Feb. 18.

At Wembley.

With so many gas engineers and their wives in London last week, although there was no set visit, many of them found their way to Wembley, and inspected the Gas Exhibit and what is being done near by to develop the interests of coke and tar. Those who mentioned to us their visits expressed complete satisfaction with what they had seen.

How to Save the Coal Industry!

Low-Temperature Carbonisation, Ltd., have issued a little booklet giving extracts from speeches and writings from various non-technical sources eulogizing low-temperature carbonization for the production of oil, and included are figures from the Fuel Research Board's report on the results of tests made at the Barnsley plant. It is not stated in the booklet that the Board are not yet satisfied as to the commercial success of low-temperature carbonization, and that they are well aware the products would be exposed to violent market fluctuations. But information is supplied as to the large imports of oil, and regarding their enormous value. The prediction is made that at the present rate of increased consumption of oil, "England's greatest industry—the coal trade—on which the supremacy of Great Britain was built, approaches its doom." How terrible! The only solution of the problem, according to the booklet, is low-temperature carbonization. It seems to be taking the system a long time to make strides in its work of salvation for the coal industry. Mention is made of what is going to be done when that 1000-ton-a-day plant at Nottingham is at work. Not much has been heard about this plant lately. Has its construction been started yet? And has the Company obtained the capital for it? No doubt the coal industry will be gratified to learn that Low-Temperature Carbonisation, Ltd., is willing and waiting to save it.

Coal Mines Inquiry.

There have been further sittings of the Sub-Committee of coal owners' and miners' representatives to consider the causes of the depression in the industry, and to explore how economies in production can be effected. The matter is approaching a head; and to-day or to-morrow a very interesting stage will no doubt be reached, and probably further developments will take place next week. The miners' leaders we believe are wise enough to see that the remedies must be internal, for nothing of an external nature can convert the industry from its state of depression to prosperity. One of the main causes of the cloud overhanging the industry is that people abroad can buy coal at a cheaper rate from other countries, and the reason for the dearness of our coal is that the costs of production are too high. That is the position in a nutshell. No one wants the earning power of the miners to be reduced; but the solution of the trouble can only be a greater production for the money earned, so that the costs per ton will be lowered. Neither side has yet formulated proposals; but there are those among the miners' leaders who say they will not accept any suggestion as to a longer working day. Supposing there is no other solution, are the miners' leaders going to allow things to go from bad to worse?

"B.C.G.A." Annual Conference.

In order that those intending to be present may keep the dates open, Mr. J. C. Walker (the Secretary and Assistant Manager) notifies that the British Commercial Gas Association's Fourteenth Annual Conference and General Meeting will be held in Plymouth on Monday, Tuesday, and Wednesday, Oct. 19 to 21. As hotel accommodation in Plymouth is very limited, and as it is anticipated that there will be a large attendance of members, the earliest possible applications for rooms is advised.

Irish Association of Gas Managers.

An excellent programme is being arranged for this year's meeting of the Irish Association of Gas Managers, which, it has been learned from the energetic Hon. Secretary, Mr. George Airth, of Dundalk (who was in London last week attending the annual meeting of the Institution of Gas Engineers), is to be held in Belfast on September 15, 16, and 17. This is a month later than the date usually fixed; but it may be explained that it is to take place in conjunction with meetings of the Irish Section of the National Gas Council and of the "B.C.G.A." There is also, at the same time, to be a big gas exhibition in Belfast. A feature of the meeting (of which full particulars will be announced later) will be an excursion to Portrush and the Giant's Causeway.

The Bournemouth Group Photograph.—Copies of the large group photograph, taken on the occasion of the visit of the Southern Association to Bournemouth, can be obtained of the photographer—Mr. J. Reade, 58, Holdenhurst Road, Bournemouth. The price per copy, including postage, is 5s.

Correction in Southern Association Report.—We regret the incorporation of an error in our report of the Summer Meeting of the Association in Bournemouth. Mr. William Cash, at the luncheon, said—*not* as given by us at the end of his speech—that he was proud that the Engineers of the Barnet, Croydon, and Worthing undertakings, of which Companies he is also Chairman, were present.

PERSONAL.

The Burnley Gas Committee have recommended the appointment of Mr. W. H. Cooper, of Harrogate, to the position of Manager of the Corporation's gas showroom.

Mr. G. F. Horsley, an original member of the Institution of Chemical Engineers, has been appointed to the post of Director of Research for the Nitrate Producers' Association of Valparaiso. The Institution of Chemical Engineers have recently successfully started an Appointments Bureau; and it is hoped that all those who have appointments to fill will place particulars of them on the register of the Bureau at Abbey House, Westminster, S.W. 1.

OBITUARY.

Sir Wilson Mappin, Bart., J.P., of Thornbury, Sheffield, who died on Monday of last week, after a long illness, at the age of 77, was intimately connected with the Sheffield Gas Company for a long period. Elected a Director in 1885, in succession to Mr. Horace Walker, he became Deputy Chairman in 1891; and in 1908, when his father resigned the chairmanship, which he had held for 35½ years, Sir Wilson Mappin was chosen for the vacant office. He devoted a great deal of his time to the concerns of the Company—not only taking his part in the Directors' meetings, but being regular in his attendance at the offices, and diligent in acquiring a detailed knowledge of the extensive business of the Company. In March, 1918, Sir Wilson resigned his position as Chairman of the Company; and his resignation was received with keen regret by his co-Directors and by the staff, by whom he was held in high esteem.

After a short illness, the death took place, on Tuesday of last week, at West Norwood, of Mr. William Joseph Dibdin, F.I.C., F.C.S. He was 74 years of age, and used at one time to be frequently before the gas industry, more particularly in connection with his extensive investigations in the subject of photometry. Indeed, at one time his books were the only ones which dealt with this matter in a really complete manner. He was also prominent in connection with standard burner questions when they came before Parliament—naturally on the side of the London County Council, to which body he acted as Chemist and Superintending Gas Examiner for a period of fifteen years. On his retirement from this position towards the end of 1897, presentations by the officers and staff of his department testified to the esteem in which he was held by them. His successor was Dr. F. Clowes, who was also well known to readers of the "Journal" in connection with his investigations on the detection of dangerous proportions of explosive mixtures of combustible gases with air, on which subject he lectured at the meeting of the Gas Institute in 1896.

FORTHCOMING ENGAGEMENTS.

[*Secretaries of Gas and Kindred Organizations are asked to assist in making this diary of events as complete and useful as possible by sending the earliest intimation of all meetings.*]

June 19.—Industrial Gas Salesmen's Circle.—Meeting at the Council House, Birmingham. Inspection will be made of the industrial gas demonstration rooms and research laboratories of the Birmingham Gas Department, and visits will be paid to the Windsor Street heat treatment shops, and to the works of the Moss Gear Company, Ltd.

June 20.—London and Southern District Junior Gas Association.—Visit to the Cambridge Gas-Works.

June 24.—Southern Association of Gas Engineers and Managers (Eastern District).—Meeting at the Institution of Gas Engineers, No. 28, Grosvenor Gardens, S.W. 1, at 2.30.

June 22-24.—Institution of Heating and Ventilating Engineers.—Summer Meeting at Birmingham.

June 30.—Last Day for Coke Competition Papers.

July 9.—Coke Oven Managers' Association (Midland Section).—Visit to the works of Messrs. Stainby and Lyon, of Knottingley.

July 20-25.—Royal Sanitary Institute.—Congress at Edinburgh. H.R.H. the Duke of York has accepted the Hon. Presidentship of this Congress, at which Sir John Gilmour, Bart., Secretary for Scotland, will preside, and deliver the Inaugural Address. A health exhibition is to be held in connection with the Congress.

Sept. 15-17.—Irish Association of Gas Managers.—Annual Meeting in Belfast.

Oct. 19-21.—British Commercial Gas Association.—Annual Conference and General Meeting in Plymouth.

NATIONAL GAS COUNCIL.

Meeting of Central Executive Board.

The Central Executive Board of the National Gas Council met on Monday, June 8, at No. 28, Grosvenor Gardens. Alderman F. S. Phillips was voted to the chair, pending the election of a Chairman for the ensuing year.

Election of Chairman and Vice-Chairmen.

Mr. D. Milne Watson was unanimously re-elected Chairman for another year, and thereupon took the chair.

The four retiring Vice-Chairmen—viz., Alderman F. S. Phillips, Mr. Wm. Cash, Mr. J. H. Ellis, and Mr. F. H. Jones—were also unanimously re-elected.

Rating and Valuation Bill.

It was reported that the Rating Committee appointed by the Central Executive Board had considered the new Bill introduced by the Government, and had come to the conclusion that, save for one or two matters which it was proposed to discuss with the Ministry of Health, the gas industry saw no objection to the Bill.

Departmental Committee in Connection with the Law on Diversion of Highways.

It was reported that representations had been made to the Home Secretary as to the desirability of public utility undertakings being represented upon the above Committee. The Home Secretary had, however, replied that, as the Committee had now held several meetings, he could not see his way to agree to any further representatives being appointed to the Committee, but he promised to see that particular attention was given to the evidence of public utility associations.

Mr. Ogilvie was empowered by the Central Executive Board to give evidence on behalf of the Council before the Committee in question.

Mains in Public Highways.

It was reported that, despite the fact that a conference was proceeding between public utility associations and highway authorities, including representatives of county councils, upon the question of mains and cables in highways, the Northampton County Council were proposing to oppose the Draft Special Order of the Northampton Gas Light Company for the purpose of inserting a drastic protective clause in favour of the County Council. It was agreed that assistance should be accorded to the undertaking in certain directions.

Local Authorities and Gas Prohibition.

It was reported that several gas undertakings were confronted with the difficulty that their municipal authority had inserted a provision in tenancy agreements that their tenants should not use gas for certain specific purposes in houses belonging to such authorities. The question was discussed as to the position of the gas undertaking should one of the tenants give an order for the installation of gas. It was agreed that this was a matter of importance to the whole of the industry, and that Counsel's opinion should be taken thereon.

Analysis of Refractory Materials.

In the "Chemiker-Zeitung" for May 16, H. Schilling gives the following method of analyzing refractory materials, which allows the rapid estimation of the iron and alumina contents: One gramme of the finely powdered and sieved material is ignited in a platinum crucible to determine the loss on ignition. The residue when cold is moistened with distilled water, about 20 drops of concentrated sulphuric acid are added, and then the requisite amount of hydrofluoric acid. The contents of the crucible are stirred gently by shaking the crucible, which is then heated, at first gently and then strongly, over the blowpipe until all fuming ceases. After cooling, the fusion mixture is added, and the contents of the crucible gently fused. The mass is then dissolved in hydrochloric acid, avoiding any excess so far as possible, and precipitated with ammonia at the boil. The precipitate, together with the filter paper, is transferred, without washing, to the porcelain dish in which the original precipitation was conducted, and dissolved again in a few c.c. of strong HCl, the operation being conducted on the steam bath with continuous stirring. The filter paper disintegrates into its fibres. The solution is diluted with distilled water, precipitated afresh with ammonia, and washed until the washings are free from chlorine. The precipitate is then ignited in a platinum crucible, treated with a small quantity of HF and H_2SO_4, and ignited in the blowpipe until all traces of fuming cease. Subsequent weighing gives the content of the refractory material in iron oxide, alumina, and titanic acid. The iron content can be estimated by dissolving the residue in HCl, filtering off the small quantity of TiO, which may be present, and titrating the iron by any of the standard methods.

INSTITUTION OF GAS ENGINEERS.

ANNUAL MEETING,

AT THE

INSTITUTION OF CIVIL ENGINEERS, GREAT GEORGE STREET, S.W.

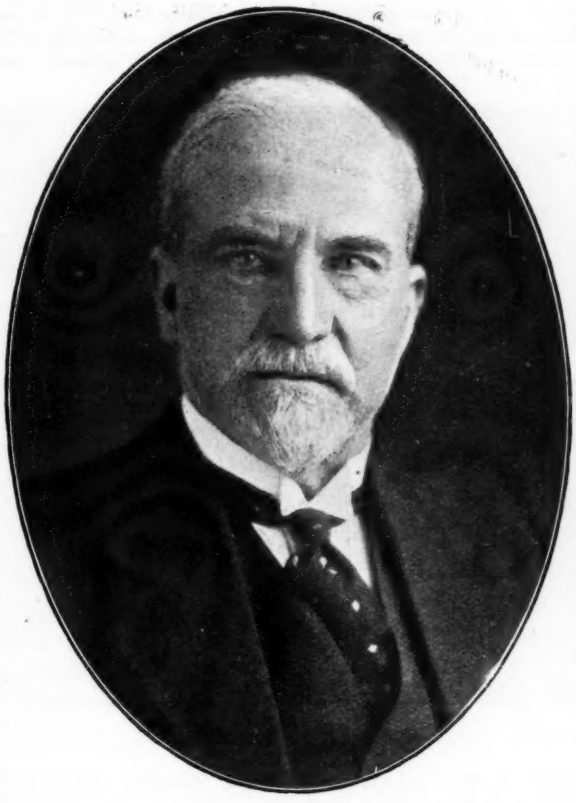
JUNE 9, 10, and 11, 1925.

President: J. FERGUSON BELL, Esq., M.Inst.C.E.

REVIEW OF THE PROCEEDINGS.

[For Full Report see p. 854.]

THE radiant morning of Tuesday of last week greeted 600 to 700 visitors to London for the Annual Meeting of the Institution; and thenceforward throughout the day and the week, the sun did its best to make things cheerful. The sun and shade temperatures on the opening day of the meeting were something to which we have grown unaccustomed; at one part of the following day it was hotter still—shade temperatures of 80° to 83° being registered in London. But no one complained; everybody merely said it was hot. There seemed to have been a conspiracy of silence about the discomforts of the intense heat; probably because there has been complaint enough about the want of sun, and when it came in bulk supply, it would have been ungrateful to say anything about it which might have appeared at all disparaging. Men come and men go; but nevertheless it seems to have become a tradition among gas men that—especially on the opening day of the Annual Conference—they should stay outside the meeting place for the purpose of greeting their friends. It has its good features and its bad. We like it because it gives an opportunity for a grip of the hand and a friendly word before getting into the serious atmosphere of the meeting room. But, on the other hand, it is not courteous to the President to let this freedom and pleasure run beyond the hour appointed for the start of the meeting. However, the Great Hall of the Institution of Civil Engineers was well filled by the time all had assembled—in fact, we doubt whether there has been a meeting numerically larger; and this is not surprising, for the membership has grown to about 1100. The Great Hall is commodious, and the hospitable accommodation afforded by the President and Council of the "Civils" is much appreciated. But many there were at the meetings who wished that that beautiful hall had better acoustic properties.



MR. J. FERGUSON BELL, J.P., M.Inst.C.E.

From general topics to others. The President (Mr. J. Ferguson Bell, M.Inst.C.E.) was prompt to time; and, despite the heat, he looked the coolest man in the whole assembly. It was a remarkable gathering that met the eye on the platform. There was not only the Senior Vice-President (Mr. C. F. Botley), the Ex-President (Mr. Samuel Tagg), the Hon. Secretary (Mr. W. E. Price), the Secretary (Mr. Walter T. Dunn), and other officers and members of the Council, but there was the Right Hon. Sir Alfred Mond, Bart., M.P. (President of the Society of British Gas Industries), Mr. W. Woolley (Chairman of the Derby Gas Company), the President of the National Gas Council (Mr. D. Milne Watson), and many others who are prominent in the organized work of the industry. Also there were gentlemen representing the gas industries of France, Switzerland, Belgium, and Norway; even India, Australia, and the United States had representatives there. It was a gathering international in composition, and bringing to a centre workers from the far-placed parts of the British Empire. Later on there was further evidence of the oneness of the world's gas industry by the presentation of a paper by M. L. Rolland d'Estape, President of the Société Technique de l'Industrie du Gaz en France, which was read in English by M. Baril. Municipal activity was worthily represented by the Lord Mayor of Manchester (Alderman Fred J. West, C.B.E., M.Inst. C.E.), who as the bearer of an honoured name in our industry, himself a keen worker, and one who has won a distinguished place in civic life, was very heartily received. There was also present the Mayor of Halifax (Alderman Waddington). Mr. H. C. Honey, the Director of Gas Administration at the Board of Trade, was another important guest.

A Welcome—Industry and Unemployment.

Some formal business was transacted; and then the President gave a warm welcome to the distinguished visitors and to the delegates from the Continent and from further overseas. What he said was endorsed by the hundreds of members, and so heartily that there was no room for doubt as to the complete and unanimous sincerity of the welcome. And as he rose to respond each speaker had a reception which was a vivid re-endorsement. Mr. Woolley responded, and so did Sir Alfred Mond and M. H. Zollikofer, who rendered as interpreter excellent service during the morning's proceedings. Sir Alfred Mond, probably under a misapprehension as to the time at disposal, spoke at length on the position of industry in relation to unemployment. Sir Alfred believes that the cause of depression in industry is the discrepancy between the cost of production and the money available for the purchase of goods. Can the gap between the two be bridged? Can we "marry" the

national expenditure on unemployment to the costs of production in such a way as to permit of the making of goods at a price which the consumer can pay? He thinks we can; and he believes the scheme he has put forward will do it. In other words, he considers that it would be far better for the country to spend part of the money now distributed in unemployment pay on bringing our products to a competitive price, so as to give the unemployed employment, than to continue to spend such large sums per annum on unemployment, and leave idle so much factory and man power and capital. Sir Alfred finds that the Swiss have anticipated him by three years by establishing a similar scheme in their watch-making industry; and the results he has suggested have been realized in Switzerland. The gas industry is deeply concerned in this question of helping trade to a greater activity, because it has a considerable business with many industries, and still spacious room for its growth to mutual advantage.

Extension of the Roll of Hon. Members.

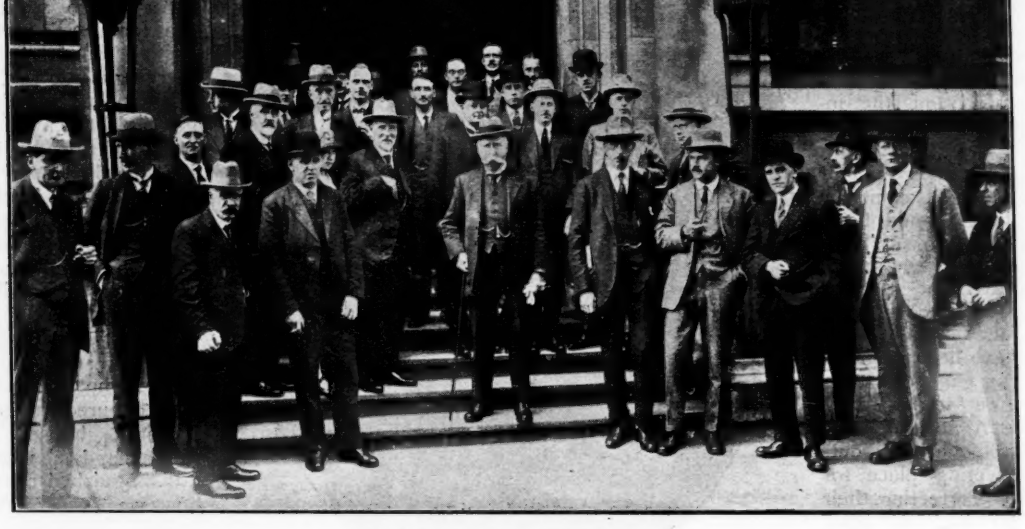
There is one thing the members of the Institution always like to do, and, when they are agreed upon it, they do it enthusiastically. That is to honour those who have earned by good work their regard in the industry. The men whom they have honoured on this occasion are not only noted for good work, but their personal qualities have endeared them to professional gas men. First that doyen in the British gas profession (Mr. Charles Hunt) was placed upon the roll of honorary members. There is no need to extol his work and his virtues. They are recorded in the pages of the history of the progress of the industry during much more than half-a-century. Then the Rt. Hon. Alderman Fred J. West, C.B.E., M.Inst. C.E., the Lord Mayor of Manchester, had similar honour done him; and he keenly appreciated this act by the gas profession to one to whom service stands as a premier duty, as it did with his revered father. Then new links were forged with the co-workers of other countries by the election as hon. members of the Presidents of the American, Belgian, Canadian, French, Italian, Norwegian, Swedish, and Swiss Gas Associations.

Presentations.

Not many men have received the Birmingham Medal, and few, if any, can claim to have won it with greater distinction than Dr. Charles Carpenter. Upon him it has been conferred this year, by a unanimous vote of the Council, and, as we expected would be the case, the complete approval of the members of the Institution. He will prize it, as he feels and values the sincerity of the applause with which he was greeted as he went to the platform to receive the coveted (by gas men) symbol of their acknowledgment of eminent services and results of work—work showing originality and genius, and results marking progress. There was eloquence in the observations of the President; there was genuine feeling and thankfulness in the reply of Dr. Carpenter. There were also in his speech words formed from a life of study and observation of the gas-making industry which will be read with both interest and profit. They are reported on a later page. The charming reference of Dr. Carpenter to the work of his predecessor on the list of recipients of the Medal—Mr. W. Doig Gibb—was one of the many points which drew applause.

Then the "H. E. Jones" London Medal was presented to Mr. R. E. Gibson for his paper of last year on "The Construction of New Coal Gas Works at Garston, Liverpool." It was a splendid engineering contribution; and the members cordially endorsed the choice by the Council of Mr. Gibson as the recipient.

The winners of the Diplomas in Gas Engineering under the Institution Examination Scheme were then called individually to the platform to receive their certificates from the hands of the President. They represent the type of men the gas industry wants.



EARLY ON THE OPENING DAY.

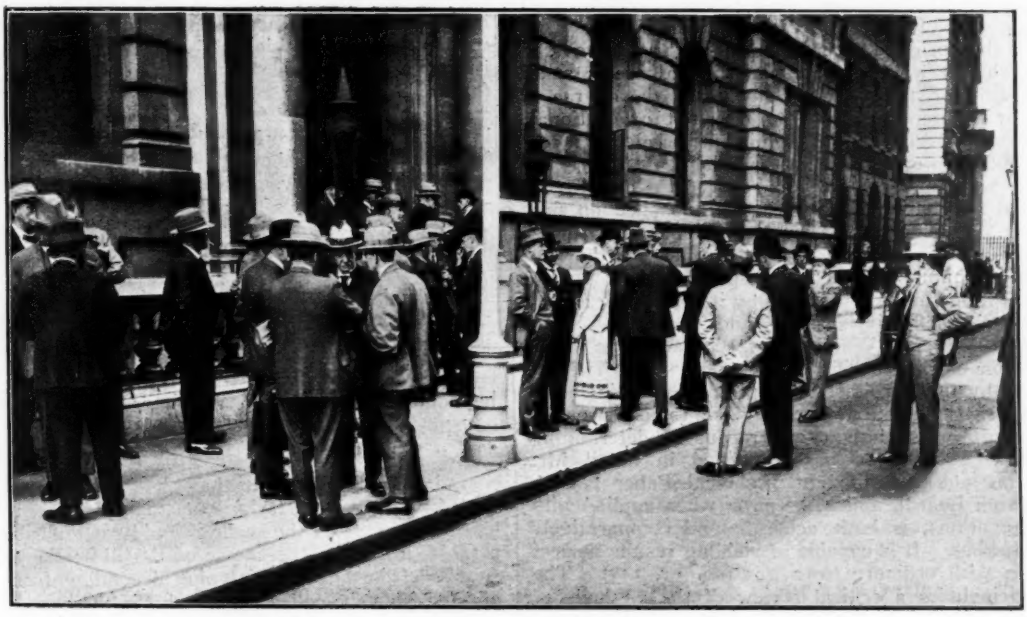
Lord Moulton Memorial Fund.

Men like to pay tribute to the work of the great by establishing some form of memorial. It is not mere impulse or passing emotion which induces them to do this; but a real feeling of affection and admiration developed during the lifetime of the man. It is so with Lord Moulton, learned not only in the law, but in science; who in 1918—following his eminent services to the nation as Director-General of the High Explosives Department—was President of the Institution. Without a memorial, Lord Moulton's name would live through ages; but a memorial will tell future generations of how his contemporaries admired this brilliant man, who nevertheless was so self-sacrificing, delightfully unassuming, courteous, and approachable. A memorial to him is going to be established, and, with the full approbation of the members, the Institution will contribute £100.

The President's Address.

The members then settled down to listen to the President's Address. In this Mr. Bell gathered together those facts which give both gratification and encouragement regarding the progress of the industry, which in latter years

has been at a remarkable rate in respect of gas consumption, though we have had a set-back in regard to secondary products, the position of which the industry is seeking to restore. But in relation to gas, what are our prospects? Never were they of a more brilliant order. But though our horizon of opportunities has been enlarged, there will not be fullness of realization of the prospects without very definite work. That work is of a dual nature, and its parts must run on parallel lines. There must be proper education and training (this the industry is developing on good foundations), and there must continue to be persistent research into materials and processes with the view of increasing efficiencies and economies. But as the President points out, a full recognition is required of the importance of economic efficiency as well as of plant efficiency. It may at times be necessary to sacrifice some of the latter in order to secure the former—for example, by the purchase of cheaper small coals owing to their availability, though in other cases it might prove an advantage to pay slightly more for materials to secure a better efficiency, bearing in mind that carriage and labour are the same for good as for poor. Every case must be judged on local circumstances. Domestic heating and the industrial field are shown in the address to be promising lines for the development of business. Power experiences in Derby are dealt with; and it is plain that the President does not think the gas industry is doing all it might in that direction. The coke position, Government assistance to electricity, and much else is treated upon—well and practically. The deliverance gives the industry a good view of the current position, prospects, and problems, which in these times force themselves—and rightly so—to a leading place in our considerations. The address receives comment to greater extent in our editorial columns. It was listened to by the large audience with marked attention and interest, and was punctuated by applause. The appreciation of the members was faithfully expressed by Dr. Carpenter.



ANOTHER VIEW OUTSIDE THE INSTITUTION OF CIVIL ENGINEERS.

Annual Report and Accounts.

Evidently the members were quite satisfied with the annual report of the Council and the statement of accounts; for no sooner were these introduced, than they were agreed to, without comment.

The Education Scheme.

Always heartily received, Mr. F. W. Goodenough, the Chairman of the Education Scheme Advisory Committee, introduced the report on the past year's work and developments of the scheme. Taking first the report. It told of how the year had been one of steady, painstaking building. There is agreement with the Committee that, though progress has been slow, it will be more sure, because of the care that has been taken. The number of centres at which organized instruction in gas subjects is being given has increased from 11 to 21, with two other centres at which the earlier parts of approved courses are being taken. Further developments in this direction are in view. Of internal and external students combined, 110 applied for examination, against 60 in the first year. There were 30 others who applied, but were disqualified owing to lack of preliminary scientific training. That is significant, and shows the want of greater educational facilities, to provide which very earnest efforts are being made. Meanwhile, the students themselves can do something to repair the deficiency. There are many matters of an encouraging nature mentioned in the report, which need not be alluded to here, seeing that the document is prepared in pithy form, and so can be easily read. There has, among other things, been elimination of the overlapping of the Institution's Education Scheme and the work of the City and Guilds of London Institute. That is an excellent thing. The scheme has also been extended, so as to provide for all grades in the industry; and this has enlarged its effectiveness.

While this important work is in the hands of such "live wires" as the Chairman and members of the Committee, with Mr. Walter Hole as the Organizing Secretary, it will always be making progress; and whenever changes have to be made in the composition of the Committee, the good qualities in this regard of the members must be maintained in the new ones. The speech of Mr. Goodenough supplied the evidence that he would be better pleased if the average of students for examination was greater than 1 to 8 statutory undertakings in the kingdom, or only 1 to 14 of all the undertakings. Of course, this ratio will, as time passes, be improved upon. But it must be said that we are not convinced that all gas undertakings are doing their part in making provision for the thorough training of men for shouldering the responsibilities of the future. In some instances, there is a preference for this work to be done by others. That may be a compliment to the "others;" but to stand aloof from doing a part is not playing the game. There is a strong appeal in Mr. Goodenough's remarks in this respect; and we should like all gas administrators to read, mark, learn, inwardly digest, and act upon what he says. He also referred to the minor grouped courses which have been organized for those who require to equip themselves well for their work in life and for higher positions, but who do not aspire to the positions of professional men.

Aeration of Lighting Burners.

It will be remembered that Mr. J. W. Wood has for some time past been following-up the subject of the aeration of burners. At first the treatment was of a general character. Last year, however, a special study was made of burners used in heating appliances; and this year investigation has been carried out on the working of typical lighting burners. Perhaps the most outstanding result of the careful examination, which is recorded in the Thirteenth Report of the Research Sub-Committee of the Gas Investigation Committee, is that the amount of primary air injected by an ordinary lighting burner, working normally with a good illumination, is only about half the total air requirement. As Prof. Cobb points out, the significance of this is that effective illumination must depend largely on how the rest of the air is supplied. This shows what importance attaches to the accessory fittings which help to determine the manner in which the secondary air is supplied. The tests were conducted at pressures up to 4 in. W.G., mainly with gases of sp. gr. 0·49 and calorific value 460-470 B.Th.U. The average total theoretical air requirement per c.ft. of gas for combustion was 3·9 c.ft. It was found that there is a rapid increase of aeration with pressure up to 2·5 in. W.G., above which further increase is small. At this pressure the quantity of air injected in the inverted burners, when adjusted for best illumination, was 1·7 to 2·1 c.ft. per c.ft. of gas, though some burners were capable of injecting 2·5 c.ft. of air. The corresponding figures were higher for the upright burner. The air-port area provided when the shutter was fully open was in no case so small as to account for a low air-gas ratio; and the degree of aeration, it is interesting to note, was not proportional, even in the roughest sense, to the air-port area after a certain size had been exceeded. The heating-up of the lighting burner when in use materially reduced the quantity of air injected as compared with the performance on first lighting-up. This amounted at times to as much as a 40 p.ct. reduction. With an upright incandescent burner, the use of a chimney exerted no appreciable effect upon primary aeration; the improvement by its use being apparently due to more effective secondary aeration.

During the year Mr. Wood paid special attention to the determination of the specific gravity of gases. The determination by the effusimeter is apt to be erratic, while the making of a complete gas analysis is a tedious process. The gas engineer should have a means of determining density; and Mr. Wood has examined in detail Mr. Blackie's method (described in Technical Paper No. 5, Fuel Research Board), which, he says, when applied with proper precautions, is both accurate and comparatively rapid in working. It is capable of yielding results correct to ± 0·002 with ordinary town gas (sp. gr. 0·5). The report also includes a critical review of the methods of gas analysis adopted in the course of the investigations. It is interesting to note that all combustions were made over copper oxide in a silica tube. The chief advantages of this method are that a much larger volume of gas can be burned than by explosion, thus giving greater accuracy in measurement; combustion can be extended over sufficient time to ensure completion; there is no careful adjustment necessary to secure the right composition of an explosive mixture; and no auxiliary supplies or analyses of oxygen are required. The combustion tube is evacuated before and after combustion, using the gas burette as a mercury pump. This is only one of many valuable observations made by Mr. Wood in an appendix to the report.

Corbet-Woodall Experimental Gas Plant.

Readers of the "JOURNAL" will remember that in April, 1924, the Corbet-Woodall Experimental Gas Plant was inaugurated at the University of Leeds. A detailed description of the plant is given in the Fourteenth Report of the Research Sub-Committee of the Gas Investigation Committee. Dr. Parker and his assistants, Mr. Kerr and Dr. Monkhouse, have been occupied in getting the plant into a proper condition for carrying-out reliable experimental work, and in making preliminary tests. Many smaller fittings necessary in an installation intended not only for demonstration purposes, but also for the investigation of definite problems, have been added. A short while ago we inspected the plant, and were able to see the many minor modifications which had been necessitated. Gas making and carbonization trials have been carried out, and the performance of the condensing, scrubbing, purifying apparatus, &c., examined. The installation, it should be emphasized, is not a small-scale model of a gas-works, but contains many features which differ from usual practice. This fact has made it necessary to conduct preliminary trials before proceeding with a definite research programme. As a result of the tests and alterations, the suitability of the horizontal setting and auxiliary plant as a carbonizing unit has been established. Dr. Parker states that tests on the vertical retort setting are now practically complete, and that it is hoped to embark on a research programme almost immediately.

As an appendix to the Fourteenth Report a brief description of a method of preparing coke sections is given. It is pointed out that the examination of a lump of coke with the object of determining its texture is normally a difficult matter. The method described, which is due to Dr. Rose, of the Koppers Company, consists in filling-in the pores and cracks of a plane section with a suitable white cement, and polishing the surface so obtained. The cell walls of the coke are rendered easily visible against a strongly contrasting background, and inert materials such as shale are clearly brought out.

After reading the report, the thought remains that there is need for action along definite and practical lines. Among the great problems confronting the industry at the present time is the production of a coke suitable for domestic use. We want to know what is the right texture which will ensure easy ignition and free burning, and how coke having these desirable characteristics can best be manufactured. It occurs to us, for example, that the vertical setting could be used for investigations having this object in view. Research workers should not become so absorbed in their work that they fail to realize the ever-changing needs of the industry. What is of first-rate importance at a certain period may after a few years become of secondary value, due to entirely changed conditions; and it is a grave mistake to devote time to a subject which has but little relation to the demands of the day, though it may be of absorbing interest to the workers themselves.

The Tankless Gasholder.

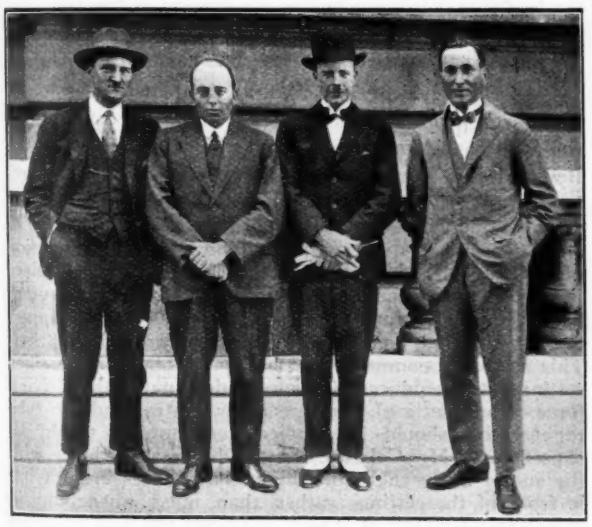
British gas engineers have now had a very thorough introduction to the tankless (piston, dry, or waterless—which adjective is to become standardized?) gasholder. The "JOURNAL" claims an early reference to the invention, in May, 1915. At that time the Augsburg-Nürnberg Company were trying-out small holders of the tankless type, in which the sealing liquid was distributed from a tank carried on the centre of the disc; the tank being supplied from an open fall-pipe depending from the roof and fed from the collecting annulus in the base. The next news was supplied by M. Bonnet's paper to the Société Technique in 1922, which must have been inspired by the commencement of work on the Douai holder. Last year the latter was the main feature of the delightful excursion from Paris; and the less fortunate members of the Institution were able to inspect a scale model of it at the "Electricals" earlier in that memorable week. At Douai M. Arbel gave a lecture at the base of the holder itself, which then became a veritable Tower of Babel as the large party of visitors climbed all over and inside it.

Now M. Rolland d'Estape, President of the Société Technique de l'Industrie du Gaz en France, and Honorary Member of the Institution, has favoured the latter with an interesting paper giving further details of the holder at the Etablissements Arbel at Douai. The capacity of the vessel is 970,000 c.ft., and could be increased by half on existing lines. The height of the structure is 118 ft. to the eaves; the diameter of a circumscribing circle is 111 ft.; and the 88½-ton disc throws a pressure of nearly 4 in. W.G. The main details of construction are well known now; but interesting particulars as to the partitioning of the sealing fluid containers and the practically fool-proof working of the pumps are given for the first time in the paper.

We remarked above that engineers in this country have now received a thorough introduction to the dry gasholder; and when our friends on the Continent are heard extolling its virtues, and the formidable list of advantages of the design is read, it seems strange that no report

comes to hand of a contract for a works in these Isles—for the economy realizable is set at 5 to 20 p.ct. for holders above 350,000 c.ft. capacity. Is it a case of insularity or our inherent conservatism and dislike of new departures? Is it distrust of the lofty and permanent structure required for a dry holder of even medium capacity? As to a large example of the design in America we have at present no definite facts or figures. Let us examine the advantages as enumerated by M. d'Estape.

The necessity for warming the tank and the cups is removed, and with it the cost of installing and maintaining a boiler and pipes for the purpose. This is something to appeal to the gas engineer of the Continent or the States, but is apt to be met with apathy on the part of the great majority of gas men whose responsibility lies in our less rigorous climate. The constancy of the pressure thrown by the disc of a dry holder constitutes a very real advantage, enhanced by the fact that by the simple expedient of placing concrete blocks upon the disc, the pressure can be varied between wide limits—in the case of the Arbel holder from 10 to 300 mm. W.G. We are reminded of the often useless (so far as pressure, but not storage, is concerned) top lift of column or spiral-guided holders, now that, through legislation, more thought has to be given to minimum pressures in consumers' services at the far end of a district. Mr. Norton Humphrys dealt with the subject on p. 254 of this volume of the "JOURNAL." As regards the next point—rigidity under wind pressure—we read that "columns can be neither completely rigid



FOUR OF THE DIPLOMA WINNERS.

Messrs. T. Dyson, T. H. Prater, C. Bateman, and T. V. Blake.

nor absolutely vertical, and the lifts of the telescopic holder are subject to violent wind stresses." That is so; but they have stood the strain extremely well. The skill and knowledge of the designers have allowed the pressure to be taken up and distributed without danger to the structures; and modifications to such essential details as the carriages of spiral holders have ensured the sweetest working even in the fierce storms which assail our coasts. Paint, of course, need only be applied to the exterior of the tankless holder, for the interior surface is continuously dressed with an excellent preservative. Comparative figures in this regard would be welcome. It should be borne in mind that the spiral-guided design has greatly reduced the cost of this service by eliminating the most troublesome part of the job; and the external flanges and the angles of the polygonal structure add many square feet to the surface and many hours of work for the painter. The foundation work is a source of great economy in the construction of the dry holder, which must account for a considerable portion of the stated 5 to 20 p.ct. over-all economy, for we learn that the "necessarily precise plating work called for by the tankless design is costly."

M. d'Estape produces but one disadvantage to weigh against the foregoing—the possible irregularity of the tar pumps, and their running costs. We are not impressed by this, for the weir arrangements in the tar wells give plenty of rope to the engineer who has a repair to do; and a few 1½-H.P. electric motors each running for a summer-time maximum of about three hours in the twenty-four do not insert an alarming figure in a profit and loss account. To the solitary disadvantage quoted, however, we would add one—æsthetic, perhaps. Some advocates of dry holders insist upon their sightliness as compared with their forerunners; but we believe that the great majority of people would rather live near, or see on the skyline, a spiral-guided holder. Its elevation is not altogether unpleasant, at times it almost disappears; painted green, it does not seriously disturb the harmony of a view—witness the Christchurch holders from the London road; withal, there is life about it. Whereas the tankless holder for ever rears its head aloft.

Points from the Discussion.

Keen disappointment was felt that the President of the Société Technique had been unable to leave France and present his paper in person; but a most efficient substitute was M. Baril, of the Société d'Eclairage, Chauffage, et Force Motrice, who admirably rendered the English translation of the paper. We must honestly confess that the discussion was as informative as the paper itself, and went strongly in favour of the tankless design. The President, in opening it, made a strong point of the dryness of the gas from these up-to-date containers. Mr. Leather indulged in mild criticism, and was followed by the heavy artillery of Mr. Milbourne. He revealed the interesting fact that the inspection galleries round these holders serve a secondary purpose in strengthening the structure against wind pressure. In praising the new design, he laid strong emphasis upon the absence of corrosion, which has caused engineers furiously to think since wrought-iron and steel plates deteriorated in quality—or town gas, as some opine. Mr. Milbourne considers that a working example is needed in this country to overcome the conservatism of our engineers; and he realizes that the tankless holder in this country has to compete with the spiral-guided design, which means that its economic cost limit must be considerably higher than abroad. Mr. G. M. Gill imparted the information that in the States, whence he has just returned, orders have been placed for dry gasholders of a total capacity of some 65 million c.ft.; two or three to be of 15 million c.ft. capacity. This news is astonishing. It is extraordinary, too, that spiral-guided holders are practically disregarded on the Continent and in America. Several minor points were then raised and answered in French by M. Baril, who was then heartily thanked for his presence and the trouble he had taken.

New Carbonizing Plant at Stretford.

The purely practical paper is a welcome necessity; and Mr. R. E. Gibson's contribution on the Garston Works last year (for which he has been awarded the H. E. Jones London Medal) had a counterpart this year in the "Selection, Design, and Construction of New Carbonizing Plant at Stretford," by Mr. W. M. Carr. Without touching upon design and construction, the author could have prepared a weighty contribution upon selection of plant alone; but he skilfully compressed a great amount of argument into a comparatively small space, and set out his case with extreme clarity. The problem of selection, he says, has become increasingly difficult during the last few years, owing to the great fluctuation in the relative values of coal and residual products; and his decision was made in favour of the type of plant best suited to meet these variations. That an extension of capacity was essential became obvious when 641 million c.ft. was sent out in 1923, as compared with 485 millions in 1921; the maximum day's sale being 2,609,000 c.ft. in the winter of 1923-24, as against only 2,138,000 c.ft. in the previous winter. Further, in view of the undertaking serving Trafford Park as well as a rapidly growing residential area, 7½ p.ct. annual increase was budgeted for instead of the more usual 5 p.ct.

With full realization of the fact that the cheapest gas is not necessarily dependent upon the highest yield of gaseous therms, Mr. Carr took into consideration his

facilities at Stretford for the purchase of cheap slacks and the low freightage which he enjoys. An extensive coke market and the necessity for high calorific value gas (in order to avoid capital expenditure on mains) were important factors. Further, in changing hands, the undertaking had already suffered an increase of 140 p.ct. in capital charges, and a close watch had to be kept upon expenditure. Such considerations left verticals, chamber ovens, and horizontals in the running. Verticals were ruled-out because of the expediency of carbonizing local slacks; and chamber ovens suffered disadvantages in that the units were deemed rather large for a medium-sized undertaking, that charging and coke handling are somewhat complicated, and that there would be a possibility of gas quality varying awkwardly between charging times. However, chamber ovens had the distinction of being compared with horizontals for working costs on a make of 650 millions per annum—taking the raw coke consumption of the former, with reversible generators and outside producers, at 12 p.ct., as against 15 p.ct. with the latter. It appeared that the extra coke yield would be almost balanced by extra capital charges, and there was the probability that the resulting coke—from carbonizing slack in the ovens—would be unsuitable for domestic purposes. The deciding factor was the urgency of the work—horizontals could be installed in a shorter time.

So horizontals won the day, and it was decided to construct a new house containing nine beds of tens (24 in. by 18 in. by 22 ft. retorts), and then proceed with rebuilding the old house with the substitution for the old plant therein of two benches of eight settings each. Thus the total capacity will be 6 million c.ft. of straight coal gas a day; the retort-houses being served by one set of stoking and coal and coke handling machinery. Before proceeding with the second section of his paper, Mr. Carr commented upon the Wollaston producers which it is intended to instal, and developed an interesting comparison of the economics of retort heating by producer gas and coal gas. The Wollaston producer has been proved to function efficiently even with coke breeze through a ½-in. mesh, owing to the fuel being passed over a series of trays by mechanical scrapers—a process which first allows it to dry, and throughout its progress permits free passage of the blast. As for outside producers in general, their heating efficiency is about 16 p.ct. lower than self-contained ones; but the possibility of employing rough slack or breeze persuaded Mr. Carr that in the Wollaston machine he had a good thing. It must be recognized that outside producers allow a portion of the gas to be used for dilution of rich coal gas.

As regards retort heating by coal gas, this is often economically possible near the coalfields (providing there is ample carbonizing plant to meet the demand for gas) for the net cost of coal approaches vanishing point under certain conditions of the residuals market. Equivalents of gas and coke for retort heating may be taken as 40,000 c.ft. and 1 ton respectively; and the costs at Stretford would work-out approximately to 2s. 6d. and 3s. 5¼d. per ton carbonized for gas and coke respectively—allowing 2½ cwt. of coke per ton. These are gross figures; but when credit is taken for the extra coke for sale which would result from gaseous firing, and a debit is made for the theoretical maintenance and capital charges of the extra plant required, the saving realizable by coal gas firing is shown as about 17d. per ton. The author points out that on the basis of the above figures, had surplus carbonizing plant been available during 1924, and the whole plant adapted for coal gas firing, a saving of approximately £4000 could have been effected on a make of 641 million c.ft. Such were the main considerations which led to the adoption of settings with normal self-contained producers and supplementary arrangements for working on producer gas, coal gas, or a mixture from external sources. For the design, Mr. Carr was jointly responsible with Mr. H. J. Toogood, of Messrs. Robert Dempster & Sons, Ltd.

In the section of his paper dealing with design, the author refers to a great many details and advances numerous valuable opinions; and it would be useless to attempt a *résumé* of the matter, which merits close study in connection with the drawings. We would, however, direct attention to the design adopted for the self-contained producers. Mr. Carr favours a producer as nearly square as possible, holding that a higher efficiency is secured therewith than with the long narrow shape. The retorts are of 95 p.ct. silica; and the keystone of the producer arch is extended upwards and incorporated as part of the elliptical combustion chamber (the complete specification relating to the latter design has just been published by the Patent Office and abstracted in our columns). The suggested procedure for changing over from coke to gaseous firing is described; and then the author goes on to discuss at some length the modified Congdon standpipes which he has installed, and the conditions he considers essential for their successful working.

In the third section of the contribution, interesting points from the actual erecting work are mentioned; and it is shown, from observations and figures collected over four months' working, that the installation will live up to expectations. Lancashire and Yorkshire mixed slacks, under 1-in. screen, worked in 12-hour charges, over a six-day experimental run gave 75·96 therms per ton of 529 B.Th.U. gas, with 12 cwt. of coke available for sale. The average inerts totalled 10·7 p.ct. The moisture and ash contents of the coal were 3·3 and 11·0 p.ct. respectively, fixed carbon 55·7 p.ct., and volatile matter 30 p.ct. The heat balance showed a net efficiency of carbonization of 82·04 p.ct. The normal weight of charge with the Fiddes-Aldridge simultaneous stoking machine is 16 cwt. with washed slack, and 17 cwt. with dry slack. Excellent testimony to the standpipe system is found in the fact that it has resulted in a reduction of the H_2S content at purifier inlet from 749 to 594 grs. per 100 c.ft.

A Good Discussion.

As the President remarked, an adequate discussion of Mr. Carr's paper might take a day, full as the contribution was with considered opinions and *raisons d'être*. Both Mr. Bell and Mr. Toogood, who followed the President, referred respectively to the author's father, Mr. Isaac Carr, as "the one who supplied the cheapest gas in the world," and "whose name is brought to mind by the very mention of cheap gas." Mr. Toogood, expert that he is, raised numerous points and stressed the fact that the author had all through kept the variable residuals market uppermost in his mind, and especially the Stretford coke market. This speaker's comments on the construction of the silica settings, the producers (which he designates the driving force of any setting), the screen-bar grates, and the tube regenerators should be studied, for a précis would be superfluous. Mr. Collett of Sheffield was at variance with the author as to coke quenching—he believes in spraying in front of the settings rather than mass quenching in skips; and Mr. W. B. Leech criticized the size of retort for the slack coal used, thinking that at Beckton the coke is better and that more therms are obtained with a smaller section. However, experiments are being carried out by the Gas Light and Coke Company, and definite results would be appreciated. Mr. R. E. Gibson, remarking upon the author's use of slacks, supports a contention which we ourselves have stressed from time to time—that if all adopt some particular method of carbonization with a certain kind of material, the price of the latter will soar, and economy through the process will disappear. The Chief Engineer of the Gas Light and Coke Company added his congratulations to Mr. Carr, especially remarking upon the success obtained with the modified Congdon standpipe. We are glad that the author in his reply took exception to Mr. Samuel Shadbolt's remark "that considerations of the conservation of our coal supplies did not trouble Mr. Carr." Nowadays, this is rather a serious allegation against an engineer; and it is difficult to see on what hypothesis Mr. Shadbolt based his comment.

The discussion had to be closed owing to pressure of time, and the author replied fully to the many points raised. More than one speaker in the discussion regretted that the paper had not been available earlier, so as to allow of fuller consideration and the sifting-out of controversial topics.

The Benevolent Fund.

First thing on Wednesday morning, consideration was given to the affairs of the Benevolent Fund. The income for the year amounted to £534 10s.; and assistance to widows, orphans, and aged members amounted to

£489 18s., and other disbursements left a credit balance for the year of only £5 16s. 11d. The demands upon the fund this year will be much greater. Although there has been a response to the President's appeal for increased funds, and one of the new honorary members of the Institution (the Rt. Hon. the Lord Mayor of Manchester, Mr. Alderman Fred. J. West) has contributed £100 for investment in favour of the fund, the Committee feel that their limited financial resources impose a great restriction upon their relief of genuinely necessitous cases.

Wrought-Iron Tubing Inquiry.

The first technical item on the *agenda* for the same sitting was the report of the Wrought-Iron Tubing Inquiry Committee, whose Hon. Secretary (Mr. R. H. Ruthven) presented it. This is a subject which has very opportunely been taken in hand. It was first raised by a letter addressed to the "JOURNAL" in 1923 by Mr. Albert Stokes, Gas Supply Manager of the South Metropolitan Gas Company. Early in 1924 the Institution forwarded a questionnaire relating to the matter to 309 gas undertakings making 100 million c.ft. and upwards per annum. Opinion is about equally divided as to whether there has been, or has not been, any decrease in the "life" of gas barrel, compared with supplies prior to or during the war. One of the questions was: "Do you specify that such material should be made from wrought-iron and not from mild steel strip?" Of those who replied 60 p.ct. specify that material supplied should be made from wrought-iron and not from mild steel strip. From answers received to a question as to whether the material is submitted to any test to ascertain its quality, it is clear that it is desirable that steps should be taken to formulate a standard test. On the evidence obtained, as set out in the appendices to the report, it is the unanimous view of the Committee that steps should be taken by the gas industry to ensure that gas barrel supplied to the industry is composed only of superior quality wrought iron. To that end it is suggested that a specification and tests should be drawn up; and for that purpose the services of a metallurgist should be commissioned. In Appendix II., reference is made to a simple etching test for the rapid differentiation of steel from wrought iron. The Committee recommend the use of wrought-iron piping; but at the same time they direct attention to the deleterious effects produced upon gas barrel—whether of iron or steel—arising from internal corrosion, due to the presence in the gas of carbonic acid, oxygen, and water vapour. It is suggested that all practicable steps should be taken to reduce to the minimum the amount of oxygen contained in the gas. Valuable accounts are given of work on the subject carried out by the South Metropolitan Gas Company and the Gas Light and Coke Company.

Interesting Comments.

As mentioned above, the report was introduced by Mr. Ruthven. It was stated by him that the Council of the Institution had not had time thoroughly to consider the recommendations of the Committee, and after this has been done, if approved, the Committee will go forward with the matter. The next thing the Committee would wish to do would be to consider and discuss the question of the specification with the manufacturers of tubes, in order to obtain their opinion. Some interesting experiences which Mr. E. F. Keable had at Gorleston during the bombardment in April, 1918, were given by him, and plates from a holder which had been pierced by enemy shells were shown, together with photographs. In our report of the discussion, we have included three of these interesting mementoes. He also supplied information as to the manner in which repairs were effected. In connection with these, the water had to be lowered in the tank, to permit of the work being executed from rafts. This gave him a good chance of examining what was going on inside the holder. He described the condition as nothing short of a shower bath. He was surprised at the amount of evaporation which took place in the holders. The water vapour was constantly rising, and forming beads on the crown, and then falling into the gas. Water troubles on the district have led him to think deeply about this matter, and, in order to reduce the evaporation, he now uses a paraffin surface for the whole of the water inside the holders. This remedied the trouble. The amount of paraffin oil used in a 100-ft. diameter holder is 120 gallons; and this is introduced just before the hot weather comes. Trouble with a 3-in. tube used in the water-feeder to a waste-heat boiler evaporating some 4500 lbs. per hour, was mentioned by Mr. H. D. Madden, of Cardiff. This tube got badly pitted in about three weeks. The curious thing about it is that other boilers have not given any trouble in this way, and Mr. Madden has not been able to discover the cause. It was announced by the President that the Committee have engaged the services of an experienced metallurgist, who has already prepared a draft specification which will receive the careful consideration of the Committee. Though the remarks made did not deal specifically with the report, it was clear that the feeling of the members was that the matter is of considerable importance.

Refractory Materials.

As usual the report of the Refractory Materials Committee is both lengthy and useful. Thanks to the Privy Council for Scientific and Industrial Research, it has been possible to present reports of the work of the British Refractories Research Association which are of special interest to the gas industry.

Of particular importance is a communication by Mr. A. J. Dale on "The Relation between Under-Load Refractoriness, Ordinary Refractoriness, and Composition, Physical and Chemical, of Refractory Materials." It has long been realized that cone refractoriness is a very limited guide to the prediction of the behaviour of a brick in a retort setting, principally because there it is under stress, and therefore fails at a much lower temperature than that required to cause the material to flow under its own weight, as in the old specified laboratory test. In addition, the time for disposal on any test of refractoriness is very limited compared with the required life in practice. Hence it is desirable that the test should yield data which can be extrapolated to eliminate the time factor. In the report Mr. Dale records measurements of the strain exhibited by both clay-grog mixtures made up in the laboratory, and sixteen firebricks representative of manufacturers' products, when heated under load up to, and maintained at, 1350° C. for two hours, and also when heated up to the temperature at which complete collapse occurs. For each material chemical and physical properties, as well as the cone refractoriness, determined by the commonly-accepted methods, are set out. It is in the interpretation of the results, together with a suggested classification of firebricks based on their behaviour under load at high temperatures, that the paper is most welcome. Each brick exhibits a thermal expansion up to some temperature, at which it is neutralized by subsidence. The point is indicated by a levelling-out of the dilatation curve; and the corresponding temperature must be regarded as being the lower limiting value of a critical range which is of fundamental importance in refractory testing. The commencement of pronounced contraction of the test piece marks the upper limit of this temperature range. By following the subsidence of the material throughout the two hours during which it is maintained at 1350° C. in the refractory load test, curves can be plotted, and from their slope it becomes possible to prophesy the extent of subsidence under prolonged heating. Also, the characteristic constants of these curves fall into three classes corresponding to the three types of failure of refractories under stress. Some products show little sign of distortion right up to the temperature of complete failure, when the test pieces shear abruptly with well-defined fracture; others very gradually deform, and at the temperature of complete failure squatt, there being little sign of fracture; while the remainder are intermediate the extremes, and show mild signs of squatt and of fracture. In consideration of refractoriness *per se*, one would recommend the first class of products but for the fact that some additional advantage in the way of reduction of porosity and reduced penetration is gained by slight subsidence of the materials; and it may well be that for refractoriness the products of class three are the

best all-round ones. Study of this and other papers shows that the assessment of the qualities of bricks can only be made by gas engineers through their own research departments, who will find papers like Mr. Dale's invaluable in pointing out the way for systematic classification of refractories according to laboratory tests, which should be coupled with large-scale experience.

Speaking of the selection of high-temperature insulating materials, Messrs. A. T. Green and H. Edwards point out that this cannot be based on insulating efficiency alone. A durable construction at the temperature and under other conditions of working is of first importance. Slag wool, for instance, should not be subjected to temperatures over 700° C. for any length of time, because of its tendency to disintegrate and form a powder, with consequent reduction in the occupied volume. This loss in structure is accompanied by a great reduction in insulating efficiency. Before selecting an insulating material it is advisable to have a complete knowledge of the circumstances of its future use, particularly regarding the face temperature to which it will be subjected. The following data will then serve well in the selection: Comparative cost, insulating efficiency, refractory test, porosity, mechanical strength, and the temperature at which the material begins to lose its structure.

The 1912 Gas Engineers' Specification for refractoriness has led to slightly variable results according to which of the two optional methods was adopted. The Refractories Committee have now remodelled the test under the title "The Gas Engineers' Refractoriness Safety Test," which is described in a paper by Messrs. T. F. E. Rhead and R. E. Jefferson. The temperature at the first sign of fusion on a cone of standard size is to be regarded as an index of refractoriness. The decision to avoid introducing a load test as employed in work detailed elsewhere in the Committee's report is claimed justifiable by the simplicity of the suggested test and the fact that any load test as now employed does not sufficiently conform with practical conditions as to be regarded as final. Attention is drawn to the necessary care in the measurement of the test piece, and useful hints for obtaining increased accuracy in this direction are given.

Other matters of considerable interest are dealt with in papers by Messrs. T. F. E. Rhead and R. E. Jefferson on "A Few Experiences with Refractories in Vertical Retorts;" and by Mr. A. J. Dale on "An Investigation of the Effects of Load, Temperature, and Time in the Deformation of Firebrick Material at High Temperature," and "Some Fallacies to be Avoided in the Standardization of any Method of Testing the Load-Bearing Capacities of Refractories at High Temperatures; and a Suggested Method for Standardization."

Need for Co-Ordination of Information.

In the course of the discussion on the report, Sir Arthur Duckham was responsible for a suggestion which was entirely endorsed by other speakers. It was to the effect that a great deal of assistance could be given by having a central committee to deal with information. In his own firm, for example, something like £3000 a year is spent in firebrick research alone; and all the information gained is absolutely at the disposal of the gas industry. This is the true spirit of research; and a general recognition of this by manufacturers in other fields would heighten the rate of progress. Sir Arthur draws attention to the excellent work being done by Mr. Rhead at Birmingham, and by the Gas Light and Coke Company. If, he suggests, we had some system of co-ordinating this work, we should make considerable headway. There is no question that refractories play a vital part in the process of gas manufacture. If, for example, we can get a plant which would have a working life of (say) fifteen years, think how this would reduce the cost of carbonization. Mr. Rhead is of opinion that, if gas engineers only realized the variations in materials, even from good firms, they would go in for testing a good deal more than they do at present. He has found that some refractory material manufacturers have erratic mixtures because they measure by the barrow load, and not by proportioning machinery. There would seem to be two extremes in this country. Some firms have reached a high degree of technical efficiency; others trust to luck that the material will come out all right—which it frequently does not! Mr. Williams, of Altrincham, asked whether a simple test, suitable for a small works, could be devised which would give an approximate indication of the quality of the material; but Mr. Leather said it was impossible, with such complex substances as refractories, to have such a test. Mr. Leech, referring to the generosity of Sir Arthur Duckham, said that, if the Institution took the matter up, they would doubtless find that manufacturers both in this country and abroad would be willing to give them the benefit of the information which they had gained. On a recent visit to the Continent, manufacturing firms had placed any amount of information at his disposal. Mr. Gill thinks that many engineers seem to forget the existence of the Institution of Gas Engineers Specification for Refractories, and emphasizes that more use should be made of it. He is of opinion that an under-load test would prove of great value. The President observed that full support should be given to the work of the Refractory Materials Committee. It mattered not how well a setting was designed, or how well it was constructed, unless the material would stand the heat and superincumbent pressure in ordinary practice it would be of no use. Mr. Leather, in the course of his reply, stressed the point that it was not sufficient that goods be ordered to a specification; it must be seen that they really were to specification.

Illumination.

The report of the Sixth Session of the International Commission on Illumination was presented by Mr. Watson, of Doncaster, and Mr. Dunn, the Secretary of the Institution of Gas Engineers. The representatives at the Conference, which, as readers of the "JOURNAL" will remember, was held in Geneva last year, numbered about 40, covering gas, electricity, and physical interests; and they came not only from our own country, but from France, Italy, Switzerland, the United States, Poland, and as far away as Japan. The papers submitted at the conference, abstracts of which appear in the report, were connected with photometric dimensions and symbols, heterochromatic photometry, factory and school lighting, and automobile lighting. One or two new features were introduced, and there was a natural transition from what may be termed the scientific or theoretical consideration of illumination to the practical application of lighting generally. Decisions were reached at the 1921 conference as to certain photometric quantities, such as luminous flux and intensity. At the meeting last year further progress was made; and definitions covering brightness, reflection, absorption, transmission, and the like were formulated, and these are included in the report. The submission of three papers on practical engineering, and methods of publicity among all classes of consumer, which referred to the various illuminants that are available to the public, was something new. Mr. Watson suggests that our own country is not behind the United States in matters of this description, and that the larger undertakings, and many of the smaller ones, are acting much on the same lines as suggested in the papers. Work at present in hand consists in the classification of streets and thoroughfares in order of illumination requirements, in the study of the means for higher illumination standards for streets, in view of the increased amount of fast-moving traffic, and the desire of increasing the height of the light source, in order to get a greater distribution of light on the ground, and to avoid the possibility of glare.

During the discussion on the report, Mr. Davies, of Chesterfield, suggested that the problem of reflection should be investigated with a view to improving street lighting. He mentioned that the electricity industry was experimenting on these lines. In regard to this, Mr. Watson said that the Sub-Committee on Street Lighting had this point in mind. Those members of the Institution of Gas Engineers who had the good fortune to visit the Physical Laboratories of the South Metropolitan Gas Company on Thursday last were able to see work of this nature in progress, the outcome of which will be awaited with interest. Mr. Ferguson Bell stressed the point that it is not by any means the intention of the Institution to lose interest in the use of gas for illumination purposes.

Effect of Ash in Coke Production.

The Gas Research Fellowship Report describes what effect the addition of 5 p.ct. of each of a number of common inorganic compounds to an almost ashless Yorkshire coal prior to its carbonization at 500° and 800° C. has upon the chemical and physical properties of the cokes produced. When carbonizing at 800° C., iron oxide, and, to a smaller extent, lime and calcium carbonate, reduce the amount of nitrogen left in the coke, while alkali has the reverse effect. The sulphur contents of cokes produced with the addition of iron oxide, lime, caustic soda, and sodium carbonate were higher than that of the "pure" coke; the greater difference being with the iron oxide and calcium oxide. Though the "iron oxide" coke had as high a total sulphur content as the "calcium oxide" coke, its sulphide sulphur content was much less. This is explained by the oxidation, during the cooling of the coke, of the ferrous sulphide to free sulphur and free iron, which latter constituent was detected qualitatively in the coke. The addition of sodium carbonate was most effective in producing a hard and compact coke of more than double the crushing strength of the unadulterated material. Iron oxide yielded similar results in a less marked degree, but the presence of caustic soda completely destroyed the coking power of the coal.

Judging from the higher volatile contents of the low-temperature cokes containing added oxides, the expulsion of volatile matter from the coal had been retarded by the presence of inert material, most noticeably with iron oxide. This is most interesting, and calls for further investigation. Alumina and silica in the proportions used appear to be without material effect on either the physical or chemical properties of the cokes yielded.

We do not think the report calls for much further comment, for it is not very fruitful as an "idea-giving" medium. It seems to us a great pity that further investigation was not carried-out on the potentialities of last year's Fellowship Report, which bristled with practical possibilities. It may be remembered that Mr. Madden, of Cardiff, asked what size of coke was most suitable for a water gas generator. This is a question which still remains unanswered; and it is just such questions as these which require investigation. A general haze of data and statistics is all very well; but research work, like all other forms of activity —be they scientific, literary, or commercial—needs to be channelled, and the concrete wall of complexity is most easily broken by repeated attack at a point which calls for immediate attention. In view of the difficulties which the gas industry is having to face, the subject of this year's Fellowship Report, though highly interesting, is, to the outside observer, not of first-rate importance.

Dr. Lessing, however, whose work on the catalytic effect of individual inorganic compounds on the carbonization of coal is well known to readers of the "JOURNAL," and who was the only speaker in the discussion on the report, certainly does not hold this view. He referred to the influence of the ash on the carbonizing process as being enormous, and held out the hope that realization of this would lead others to pursue this line of investigation. As to the report itself, he referred to it as an exceedingly important piece of work, and said that in general the results put forward confirmed his own working. Dr. Lessing is of opinion that all work on carbonization will have to be reconsidered in the light of the influence of the inorganic constituents of coal on the yields of volatile therms in the form of gas and tar. After voicing a warning to the effect that the values for crushing strength of cokes determined on small specimens should be treated with great caution, he called attention to the method of carbonizing coal in the form of fine particles which has been adopted by H. E. Newall and F. S. Sinnatt, who, as was mentioned in the "JOURNAL" for Jan. 7, state that heating first produces an ordinary large bubble structure, followed by the production of hollow spheres, known as "cenospheres." Dr. Lessing thinks that this method of attack may yield fruitful results.

Gas Testing in Small Country Places.

Prof. C. V. Boys has the priceless gift of holding the attention of a large audience. Those who had the good fortune to be present at the meeting of the Institution in 1922 will understand what is meant by this short sentence, and will remember the delightful account which he gave of his recording calorimeter. At that meeting all were impressed with the amazing fertility of Prof. Boys' mind; and the paper on "Developments in Gas Calorimetry" which was read at this year's meeting of the Institution is another reflection of his wealth of ideas. He mentions that, in carrying-out their duties, the Gas Referees have been oppressed by the cost and elaborate procedure which have grown up round the ordinary water-flow calorimeters, and which make their provision a serious burden in small country places. This applies less to the equipment within the testing place than to the time required of the gas examiner and the tedious nature of the operation which he has to conduct. With a view to reducing this burden, Prof. Boys has designed a simple equipment which he describes in detail in his paper. As one would expect, it is a highly ingenious and carefully thought out piece of apparatus. In small undertakings, when financial considerations unduly limit the number of tests, it is difficult to find a value for the average calorific value of the gas supplied; and if the number of tests is too small, there is a risk that the gas may, on the few occasions of test, be caught at an unhappy moment when it is in a state of depression. As Prof. Boys points out, tests at such times may not be balanced by others more favourable, with the result that the average calorific value reported may be less than that actually supplied. It is not possible to remedy this state of affairs, because the cost of the tests becomes an item in the local rates. As it is, it is only too often found that the limited number is considered excessive by the local authority. The consequence of all this is that small gasworks have to provide gas which on the whole is of better value than that actually declared, if they wish to be safe from adverse report. It is to reduce this hardship that Prof. Boys has brought forward his simplified testing appliances. This, however, is not all. He indicates a further possibility of obtaining a fair average value by a method of sampling, and suggests that in small country places the gas should be slowly and continuously drawn into a small holder in the testing place, and that the gas examiner should make a test on the gas which should be an approximate average of all that has been delivered since his last test. This suggestion will doubtless be well received by the gas industry. The final portion of Prof. Boys' paper is a description of a special gasholder for this purpose. If this system should work out well, the more important object of the Gas Regulation Act would be attained—and this for the smallest place and at the minimum cost.

Comments on the Paper.

As was to be expected, there were many appreciative remarks on the skill and ingenuity which Prof. Boys had exercised in bringing his ideas to a practical issue. Mr. Whipple, of the Cambridge Scientific Instrument Company, who remarked that the invention was characterized by simplicity, was impressed by the manner in which Prof. Boys had circumvented insulation difficulties. To his query whether Prof. Boys had tried diatomaceous earth as an insulating medium, he received the reply that this substance, though, of course, well known to the inventor, had not been used. The insulating material employed, cork, is entirely safeguarded from the effects of moisture. Prof. Cobb added his unqualified appreciation of the work done by Prof. Boys, at whose hands, he said, complex questions received simple solution. Dr. Colman, Dr. Parker, and Mr. Wood all referred to the question of deterioration of the gas on standing for a lengthy period over water. Dr. Parker wondered whether this difficulty could be overcome, at reasonable expense, by the use of a mercury seal, and made a most interesting observation to the effect that the gas might diffuse through the water lute, and eventually find its way to the atmosphere. Regarding this, Prof. Boys thought the rate of diffusion would be very low, and mentioned that after gas had been stored in the sampling holder for a fortnight no change had taken place. Mr. Wood, on the same question, suggested that, as a result of polymerization of certain of the compounds in the gas, it was conceivable that a solvent would settle on the water. Dr.

Colman drew attention to experiments which he had conducted, and said that in a holder similar to that of Prof. Boys he had never been able to find a definite loss greater than about 1 p.ct. His tests, however, were insufficient to constitute proof; and he suggested that the problem should be thoroughly investigated. Mr. Wood asked what provision was made for preventing the holder from being filled too quickly, and how the contents could be "backed-out" if the supply failed. Prof. Boys, in reply to this, said that the rate of filling was entirely governed by the clockwork mechanism, and, by a clutch device, "backing-out" was allowed for. Part of the discussion centred on the method of arriving at an average sample of the gas made or sold, and whether synchronization of an accurate nature was possible—Prof. Boys intimating that practical consideration should dominate, and that absolute perfection could not be gained, even by incorporating "Heath-Robinsonian" notions; Dr. Smith received confirmation of his suggestion that the apparatus would be suitable for both large and small works. The discussion was greatly enjoyed by a crowded meeting.

This concluded the afternoon sitting on Wednesday. The following morning two highly important papers and discussions occupied the greater part of the sitting.

Town Gas for Motive Power.

A contribution from Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., Past-President and Honorary Member of the Institution, is always particularly welcome; and the short paper on the above subject which he presented was fully optimistic and most encouraging. Town gas for engines has deservedly been more in the limelight during the past year; but few realize that the proportion of that commodity used for motive power in Great Britain and Ireland amounts at present to about 10 p.ct. of the total make, and produces one-half the brake horse-power of all the internal combustion engines in our factories. Sir Dugald looks forward to a continued increase as external, and so internal, trade recovers from the cataclysm of the war. But all must do something towards this recovery, as we heard from the lips of Sir Philip Cunliffe Lister and Mr. Milne Watson last week; and every effort should be made to reduce the price of town gas for power purposes—4d. to 6d. per therm is too high to compete with other sources of power above 100 B.H.P. From 5 to 100 B.H.P., however, one great point in favour of the town-gas engine is that the efficiency remains practically constant under varying loads. The comparative cost figures, given in the paper, for various sources of power, including interest and depreciation, water, oil, and labour, are: Town gas, 0·75d. per B.H.P.-hour; anthracite (suction gas), 0·52d.; coke (producer gas), 0·49d.; and Diesel oil, 0·47d. For electricity, allowing 90 p.ct. motor efficiency, Sir Dugald prescribes a price up to 1·125d. per unit in order to compete for power.

Towards the end of the paper, the gas industry is strongly urged to push forward in this field. Gas undertakings must bring pressure to bear equal to that of their competitors; and the opinion is voiced that even the very small power trade might be held if the engines were let on hire. The gas industry has an excellent example in this direction from the President and the Derby Gas Light and Coke Company. Sir Dugald saw in the Gas Regulation Act the chance of varying methods of manufacture so as to supply a gas equally suited for lighting, heating, and power purposes; and with the same broad view he calls upon gas engineers to study the whole subject of fuels—not only town gas—for he looks forward to the discovery of further useful carbonaceous material in the wilder countries of the earth.

Further Encouragement.

It was doubly appropriate that the President should open the discussion on the above-mentioned paper, for the Derby Gas Light and Coke Company are really showing the way to the development of the power load. Mr. Bell stressed the advisability of regularly inspecting and indicating engines on the district. It is well known that he advocates free fixing and hire-purchase and simple hire terms. While not in favour of pushing differential prices to extremes, he considers that power tariffs should be cut as far as possible; and he would like to see the larger undertakings co-operating with the smaller ones in providing an expert inspector and adviser. At Derby it pays well to have such a man canvassing the district.

Mr. George Helps confessed that he had lost business to oil because he could not sell the gas therm for 3d.; and Mr. P. D. Walmsley introduced the subject of generating electricity by gas so as to counter the business our competitors do with the "individual drive." Mr. Samuel Shadbolt complained of such practice by the electricians as charging, through a special arrangement of bulk supply, from 0·75d. to 0·9d. per unit for power and 6d. a unit flat rate to shopkeepers for lighting on the same district. This is certainly drawing a very long bow (which might break one day); but Dr. E. W. Smith looks a hard fact in the face, and suggests an inquiry by the gas industry to determine the practical means of differentiating gas charges.

Mr. Tookey contributed several useful points. It was good to hear that many who introduced suction-gas plants when the latter came into vogue were now abandoning them in favour of town gas; also to learn of a manufacturer who finds it cheaper to run three small gas engines—theoretically inefficiently—than to take current from the public mains. Further, to have one's own gas-driven generating plant is a safeguard against strikes outside; but a client should be given a proper maintenance service.

We commend to all the verbatim report of the discussion; it will repay careful consideration, and there is much of encouragement therein.

Economics of Gas Production.

The paper by Mr. George Evetts is characterized by common-sense—a quality which is, perhaps, of all qualities the most difficult to attain, and which is the outcome of hard thinking and a broad outlook. The keynote of the paper, the subject matter of which constitutes a striking refutation to the claims of those who, without considering ultimate effects, point unhesitatingly to this or that means of salvation in the gas industry, is "it all depends." Mr. Evetts points out that calculations based on the volume of gas or the tonnage of coal are only useful in so far as they deal with the plant or machinery handling such volume or tonnage, and to this extent affect the working costs. Finally all results and costs must be reduced to the therm. How often do we hear of Chairmen of Committees congratulating themselves that they have made more cubic feet of gas per ton of coal carbonized than they did in a previous year—a statement which, without qualification, signifies nothing. Many discussions have taken place on the variation in the volumetric sale due to changes in calorific value, and statements have been made to the effect that consumers have used the same volume of low-grade gas, compared with corresponding periods when a higher grade was supplied. Mr. Evetts is of opinion that these statements would not bear investigation, and that volumetric consumption increases as the calorific value decreases. He quotes an example. The calorific value was 540 in 1913, and 375 in 1921. The sale in the meantime had increased by 50 p.ct. In other words, 540 therms in 1913 had risen to 565 in 1921, and the thermal sale per consumer was practically unaltered.

The basis of all calculations is the demand for thermal units; but the gas-maker cannot dissociate volume from his considerations. Exhausters, washers, purifiers, holders, &c., are limited in regard to volume. For this reason, though a low-grade gas may be cheaper to produce in the retort house, it may be dearer to sell. Taking gasholders as a case for comparison, assume that the maximum daily demand is 10,000 therms (1·82 million c.ft. of 550 gas). Gasholder storage of 1,600,000 c.ft. would represent 88 p.ct. of the maximum day. If the quality were lowered to 400 B.Th.U., the thermal storage would be reduced to 64 p.ct. of the maximum. To reach 88 p.ct., as before, additional storage of 600,000 c.ft. would be necessary—costing about £15,000. This would add 1·4d. per therm to the capital cost per therm sold per annum (based on 250 maximum days per annum).

Then there is the capacity of the distribution system to consider. Advocates of low-grade gas argue that distribution difficulties can be solved by increasing the pressure at the works; but, as Mr. Evetts emphasizes, the

fact remains that with a higher quality the increased pressure would deal with still more gas, so that a main of given size has a reserve of potential power if the calorific value is increased. Already in many cases gas undertakings have a stiff task in supplying consumers' needs; and this point should be borne in mind. It is shown in the paper that, taking an 18-in. main, 3600 yards long, 166 therms per hour are delivered with a 2-in. pressure drop when a gas of 290 B.Th.U. is supplied, whereas, with a gas of 564 B.Th.U., 390 therms per hour is the delivery figure. Dealing with distribution, Mr. Evetts points to the advantage of erecting outlying holders.

Throughout the paper the author does not merely state opinions; he gives the why and wherefore of them, backing-up his arguments by statistics. He lays stress on the need for taking local conditions into account when adopting any policy, and shows how it may be better in certain circumstances to make 10,000 c.ft. of gas per ton rather than 12,000 c.ft. He demonstrates that the maximum production of gaseous therms per ton of coal is not always the cheapest method of manufacture. With regard to the maintenance, repairs, and renewals of purifying plant, gasholders, &c., it is clear that a low-grade gas would necessitate a larger piece of plant in each case; and consequently fuel, oil, paint, and general attention would be more than in the case of a higher grade, and the costs of repairs and renewals would be greater. These points may appear obvious; but it is only too true that they are often taken into consideration after the event, rather than before. Speaking of leakage, Mr. Evetts says that it is probably unaffected by the grade of gas supplied. Low grade requires higher pressures, but a certain sized orifice would deliver no more thermal units in a definite time, for the increased volume lost would contain less heat units per cubic foot. The paper is full of useful and well-balanced observations; and it is hoped that these few notes will serve to indicate its general trend and its practical value.

THE NEW PRESIDENT.
Mr. C. F. Botley, of Hastings.

Low-Grade Gas.

In the course of the discussion which followed the reading of the paper, several interesting remarks were made by advocates of low-grade gas. Mr. Robinson quite rightly drew attention to the tendency to adjust calorific value in accordance with market conditions. When coke is good, it pays to distribute high-grade gas. At times when residuals fetch poor prices, the leaning is towards gas of a lower calorific value. But what about the consumer? Are these fluctuations either desirable or necessary? Mr. Robinson thinks the policy should be to reduce the amount of coal carbonized and coke produced, and thus attain greater stability. Mr. Shadbolt, of South Bank, on the question whether a cubic foot of 500 B.Th.U. gas performs the same duty as (say) 2 c.ft. of 250 gas, said that, though this might, and did, apply to power consumption, it was by no means so reliable where the domestic load was concerned. Mr. Shadbolt also referred to leakage. He considers that when Mr. Evetts states that a certain sized orifice will deliver no more thermal units in a certain time, as the increased volume lost due to higher pressures would contain less heat units per cubic foot, he assumes something which does not materialize in actual fact. Mr. Shadbolt has found in his area that an increase in pressure has been of assistance in keeping-down the figure for unaccounted-for gas—a remarkable experience. At South Bank, taking the calorific value now (400 B.Th.U.) and before the war (500 B.Th.U.), while the volumetric loss remains the same, the thermal loss has been reduced 27 p.ct. Mr. Marshall had a good deal to say about his low-temperature process, and suggested that low-temperature carbonization should be linked-up with gas-works practice, if success was to be assured. On this point Dr. Smith made the pithy observation that, if such a process is unattractive outside the gas industry, the industry will require a lot of convincing that its adoption would be worth while.

Official Advancement.

Then we heard the report of the Scrutineers upon the election of office-bearers, and new members of the Council. The expected happened. The members had the great pleasure of welcoming Mr. C. F. Botley as the successor of Mr. Ferguson Bell in the Presidential Chair; and an eloquent acknowledgment was made by our friend from Hastings. Mr. J. Wilkinson has been advanced from the Junior to the Senior Vice-Presidency. It is a happy procedure which allows a gradual stepping-up to the duties and responsibilities of the supreme office in the Institution, as it enables one to get thoroughly well-grounded in them. For the Junior Vice-Presidency, Wales has supplied a worthy successor to our Nottingham friend—Mr. H. D. Madden, the Engineer and General Manager of the Cardiff Gas Company. That long-experienced active worker in our organizations, Mr. W. E. Price, with that never-failing geniality of his, once more accepted the office of Hon. Secretary.

Thanks All Round.

Then the sittings concluded by richly expressed thanks to the President and Mrs. Bell—to the former for his work during the year and through the meeting, and to both for the magnificent hospitality and pleasure which they have given to the members. The Chairman and Directors of the Derby Gas Company were thanked for the great favours to come on the Friday. There was an "omnibus" resolution which thanked everybody who deserved such recognition; and then there was a special vote to that paragon of a Secretary, Mr. Walter T. Dunn, who, as we announced in last week's issue, starting as he did as a young man on the work, has now seen through thirty annual meetings for the Institution. And in his duties, those who are best qualified to judge certify that time increases his value. The President and the Council of the Institution of Civil Engineers were very cordially thanked for their generosity in placing so much of their fine building at disposal for this meeting, the proceedings at which had been of such varied interest and of such excellent quality.

In the afternoon of Thursday visits were paid to the Fulham Gas-Works of the Gas Light and Coke Company, the Laboratories of the South Metropolitan Gas Company, and the National Physical Laboratory; and on Friday to Derby. These are items in the programme which are dealt with in special descriptive accounts elsewhere.

GENERAL REPORT.

The Annual General Meeting of the Institution was held on Tuesday, Wednesday, and Thursday of last week, June 9 to 11, in the Great Hall of the Institution of Civil Engineers, Great George Street, Westminster, S.W., under the Presidency of Mr. J. Ferguson Bell, M.Inst.C.E., Chief Engineer and General Manager to the Derby Gas Light and Coke Company. He was supported on the platform by many gentlemen who are known personally or by name to everyone connected with the gas industry.

Welcome to Distinguished Visitors.

The President (who was loudly applauded on rising) said: Ladies and gentlemen, I am delighted to see so many present at our opening meeting this morning, and regard it as auguring a good and successful gathering. Before we commence the ordinary proceedings, I am sure you would like me, on your behalf, to offer a very cordial welcome to the many distinguished visitors who have been good enough to accompany me on to the platform. Not only have we visitors from New York, Australia, New Zealand, the Continent, and other parts, but we have also honouring us with their presence gentlemen here who are eminent in various spheres at home. I can assure them that we very heartily appreciate the signal honour they have done us in coming to this meeting. The industry which the Institution represents is one of the largest and the most important of our public utility services; and we are glad to find these gentlemen agree with us that it deserves encouragement. The capital invested in the gas industry and allied trades is something over £200,000,000 sterling; and it gives practically permanent employment to somewhere about 125,000 men. In these days of unemployment the latter is, I think, a most important factor. ["Hear, hear."] We are specially honoured this morning by the presence of my friend Mr. W. Woolley, the Chairman of the Derby Gas Light and Coke Company. Mr. Woolley is well known in Derby, and takes a great interest in all that concerns the Company over which he presides. I should like to take this opportunity of thanking him for all his assistance and the very valuable advice he has given me during the last twelve months. I was also expecting to see on the platform both the Members of Parliament for Derby; but the Right Hon. J. H. Thomas has evidently been delayed. We are glad to have with us the Lord Mayor of Manchester and the Mayor of Halifax. It is a real pleasure to me on your behalf to offer all these gentlemen a very hearty welcome. I will not occupy your time by going over all the names. Before we get on with the business, I will ask Mr. Woolley to say just one or two words.

Mr. William Woolley: I am very pleased indeed to come here this morning, because I feel that, in electing Mr. Bell your President, you have not only conferred upon him an honour which he so well deserves, but you have honoured the Company he serves, and has served so well for many years. I feel sure under his Presidency you will have a most successful meeting. I trust when your labours are over under his guidance, I shall have the pleasure of seeing nearly all of you at Derby on Friday.

Mond Scheme of Maintenance with Work.

The President: I will now ask Sir Alfred Mond, whom we are delighted to have with us, to address you. Sir Alfred Mond is known, not only as a prominent politician, but as a scientist and a successful industrial magnate—with a lot more of whom the country could very well do. In putting forward his attractive proposals for subsidizing employment, he has performed a great public service. The obvious advantages of maintenance with work over maintenance without work are now recognized by all parties; and we shall therefore be interested to hear what he may have to say on the subject.

Sir Alfred Mond, M.P.: I feel very honoured that I have been asked to address a few words this morning to such a very important gathering; and I will, in the first instance, say how relieved I am to hear your President state that we want a few more successful industrialists in this country. When I think of all the criticism we get to-day for success [Laughter], and of the abuse we suffer from if we show any profits at all, I sometimes wonder whether I do not belong to the criminal classes of this country. [Renewed laughter.] I once said that the only meritorious method of carrying on a modern business seems to be either in liquidation or in the Bankruptcy Court. At any rate, as soon as somebody makes any kind of success, he is denounced either as an exploiter or a profiteer; and that is a very discouraging atmosphere, I frankly must say, to all of us who are engaged in the very difficult and anxious task of endeavouring to maintain British industry under present conditions. I do not think the outside world at all realizes the anxiety and the work that is involved in conducting modern industrial enterprises. You have not merely to watch one country, or home competition, but you have to watch to-day the inventions of the entire world. Competition is now arising in quarters as remote as the Far East; and new ideas which you have to examine are being put into operation by able technicians of all countries. The task to-day is a thousand times more difficult than it was even fifty years ago; and there is another point that is not adequately realized—that no civilized country to-day has got any monopoly of technical efficiency, capital, or trained labour. Therefore, the task has become infinitely more difficult, and we who have been used to considering that the world existed in order to buy our exports, and to buy what we chose to send, now find ourselves faced with a world situation in which it becomes more and more difficult to induce people to buy our goods; while the war has produced national industries in countries often very little fitted to carry them out. At the same time these industries, once they have come into existence, will not be allowed to drop out. Therefore, you have this additional difficulty of restriction, I might say, of our export endeavour. We have succeeded in maintaining a magnificent currency and credit, combined with bad trade and unemployment unequalled in any country in Europe; but I do not think it is always recognized that the interests of high finance and the interests of business are not necessarily identical. Some people look at this country as a country which exists for the purpose of granting foreign credits; but I am in the habit of regarding it as one which has got to employ some 14 or 15 million workmen. It is these divergences of standpoints which make us industrialists not always agree with the pundits of high finance as to what is in the best interests of the country.

I have had to devote during the last few years, both officially and unofficially, a good deal of time to this problem of unemployment. Many of you know that in Mr. Lloyd George's Administration I was Chairman of the Cabinet Unemployment Committee for some two years. Most of the measures of alleviation which have been put into practice, such as trade facilities, export credits, grants to local authorities, and a number of other things, are really the fruits of the labour of that Committee, and have been continued ever since; but there is one thing when you come to work at this problem in detail which everybody finds—that the creation of artificial work is both costly and difficult. You can induce local authorities to dig useless ponds and fill them up again; you can have quite good schemes for the reclamation of land, and things of that kind; but there are great difficulties and cost involved in getting your raw materials on to the spot which makes the total cost of such schemes prohibitive. Another point not fully appreciated is the large amount of capital required in any industry to employ one workman. When you come to work out some of these

schemes, the difficulties are really very great. Therefore, my mind has always been turned to the problem: Why cannot we employ an unemployed workmen, not on the making of roads or in the reclamation of the Wash, but in the factory in which he is usually employed, which requires no new organization, and no displacement of the economic method of giving a man the job he needs in the factory he is used to, where the capital has already been expended and is lying idle? Obviously, if you can, you will save money by obtaining greater value in the way of increased production, and at the same time you are rendering a much greater service to the man in question. Why are industries depressed? We are experiencing difficulties in exporting and in selling goods abroad; and to what is that due? It is due to the fact that our prices are too high for the purchasers. There are two reasons for this. Exchange is one. Then, as we all know, the poverty produced by the war in the world is another; and the question is, How can we bridge the gap between what I might call cost of production and purchasing capacity—not demand, because the demand is there all right? That, to my mind, is the fundamental problem; and that gap is not always so wide as people imagine. I have had case after case illustrating this. I had a case in shipbuilding recently, in which the Chairman in this country of a very large American undertaking had some ships to place; and we were in competition with, of all people, the French. The difference between the British and the French tenders was not very big. On one tank steamer of considerable size there was, perhaps, a difference of £30,000.

Now, at the same moment that you hear of an order which you could get for that difference, you see, on the other hand, thousands of unemployed walking about the streets, and being paid from 18s. to 23s. a week for doing nothing at all. You are spending £100,000,000 a year in the country by paying something like a million of people for doing nothing; and really I cannot understand a business nation going on doing that. Since the war, you have spent more than £300,000,000 in cash, for which you have not one penny in assets. It has all been spent on unemployment relief; and therefore it is that I ask why we cannot in some way marry this sum now being paid in unemployment relief with the cost of production. By enabling our cost of production to be reduced, we can obtain more work. That is the problem in a few words; and I have devoted a great deal of time and thought to a method by which this can be done. I do not say that you can work out in advance every possible detail; but I think I have worked out the scheme in sufficient detail to say that it is practicable. It is based on three or four very simple considerations. First, it involves the surrender of the unemployment allowance as a voluntary matter on the part of the workman, because I think it would be fatal, when a man is entitled to an unemployment allowance, to pass any legislation which would take away from any individual person anything to which he is entitled. Secondly, you must get more people employed than is the case at present; and you must make it impossible for any employer to substitute a man who is employed to-day in the ordinary way by what I might call a man subsidized by unemployment relief. I think my scheme is absolutely watertight on that point. Therefore you are not merely substituting employment in one factory for unemployment in another; and it is for that purpose that I have created somewhat elaborate machinery in the form of trade committees, whose functions will be to watch three cardinal points. Any employer who applied for permission to enable him to obtain what I might call a workman with his unemployment allowance would have to prove to the trade committee that the contract he wanted to take was new work, and that he would not be taking away work from another factory. Many people think that is very difficult; but in the kind of industry which I have visualized, like engineering—of which I know a good deal, because I have been Chairman and Director of engineering firms—and shipbuilding and big industries of that kind, and even the gas industry, it is not so difficult. Let me give you a particular instance. I am interested, as I dare say a good many of you know, in a firm which has done a great deal of work in the gas industry, Messrs. Ashmore, Benson, Pease. We have got some contracts for big gasholders in Canada. It would be easy for a firm like this or any similar firm to show that, if a contract in competition with America or Belgium or any other country, could be obtained on certain terms, we could employ so many more men than we are employing to-day. I am always being told that all I am doing is to transfer a contract from works B, which is less efficient, to works A, which is more efficient; but my answer to that is that what I am doing is to get the contract for works C, and that under present conditions works A and B would never get the contract. If, therefore, works C gets this work, you obtain very much more work and more employment. My scheme is designed admittedly to enable us to help works C. It would also apply to any local authority and to any public utility undertaking with limited dividends under an Act of Parliament, like a gas company. Any company like this would be able to take on more men; and as you are taking away, nothing from anybody, you are simply extending business. Indeed, I have had letters from engineers of gas companies saying that they would be able to employ more people and extend their undertakings immediately if my scheme were in operation. What does the scheme amount to? It would mean a wage reduction by the amount of the subsidy during the time of the employment, but not a wage reduction to the workman. He would have to be paid at the usual district union rates. He would not be paid a penny less, and he would have to be engaged for a reasonable period. His position would be entirely safeguarded, and instead of the Unemployment Fund paying money to men who are not engaged in any work at all, and giving these men the inadequate and miserable pittance which they receive to-day, and which is often supplemented by the Poor Law Guardians, the men would be earning £3 or £4 a week. Now what would happen if this state of things came about? As soon as you put people back to work, and pay them decent wages, they become consumers; and by doing this they help other industries which are not in the scheme at all, and produce employment in these other industries. The moment you start employment anywhere, you get ancillary employment in hundreds and thousands of directions, and you get a reduction in employment of a very considerable size. I was interested to learn only yesterday that the Swiss Government have anticipated my idea by three years. The Swiss watch industry, which was a big export industry, was almost ruined, because, though the Swiss had a good exchange, they had to sell to countries with a bad exchange. The Government had to do something, and they did not sit down and say there was nothing to be done. They worked out a scheme, not exactly in the same detail as mine, but on the lines of subsidizing the watch industry as regards those countries where the currency was depressed. In one year they reduced the unemployment in the industry by one-half, and at the same time they reduced the general unemployment in the country to a considerable degree. It is very interesting to find that an idea of this kind has been put into practice by a small but intensely hard-headed and practical nation such as the Swiss, and has proved that the results which I have deduced would occur have actually occurred. Personally, I cannot understand the timidity of those responsible for our Government which prevents an effort to start a scheme of this kind. I am perfectly well aware that there will be difficulties, and that there will be complaints. There will always be difficulties, and there will always be complaints; and you will never get everything perfect. That has never been done in the history of the world. But in considering a scheme of this kind, surely, when you have got to a condition almost of stagnation in the unemployment of one million people, when you see the devastating results it is having on the efficiency of the workers in this country, when we know that a great many of our best workers have left, and others will continue to leave, these shores, it is time that timidity and hesitation are put aside, and audacity and enterprise substituted. People who know nothing about works and workmen have curious ideas. They seem to think that you can keep both idle, and, when trade improves, suddenly start up to 100 p.ct. efficiency, as if nothing had

happened. All of us who have to carry on works, however, know that is not true. We all know that, if a works is shut down, an extraordinary deterioration takes place, even with the greatest care. We know that staffs, once dispersed, are extraordinarily difficult to re-create. We know that if the best skilled workmen have gone to America they are not coming back just because we want to give them a job. What I fear is that, if industry does improve, we shall find we are not in the position of having the means of meeting it unless, in the interval of depression, we have enough foresight to keep our men in a state of efficiency. After all, we have an army in peace time to defend our country, and that army is highly trained, in order to operate on those unusual and rare occurrences when war takes place. I wonder what any member of the General Staff would say if I suggested to him that it was not necessary to worry about drill or musketry or manœuvres or anything else in peace time, and that these things could be thought of when the occasion arose. The industrial army, in a sense, must be quite as efficient as the military army, and your reserves must also be kept in a condition of efficiency, so that when you want to mobilize them they can operate. What we are doing also is to deteriorate the efficiency of the men at the other end. I mean that we have hundreds and thousands of men who have been trained for nothing, and year after year are becoming absolutely useless. When these men were wanted to fight for the country, there was nothing in the world we were not prepared to do for them. Anybody who likes to go back to that period will see what we said then. Many of these were young men who went straight into the army, and could not be apprenticed and learn any business; and it is a perfect outrage that they have been allowed to walk the streets year after year since. I say it is a national shame that nothing has been done for them.

Therefore, I want this project of mine looked at not merely from the economic standpoint, although there I think it is sound, and still less from the standpoint of the private individual and private interest and private profits, but from the broad fundamental national outlook of the country. The responsible people in this country have got to ask themselves one simple question—how far can we go on as we are to-day? Can we go on any longer? And if we cannot, is there anybody who can put forward a better than the scheme I have outlined, a more practical scheme, and one more likely to achieve results? That is what I want an answer to. If there is a better scheme, let us have it; if there is not, let us proceed with this one. Of one thing I am certain, and that is—you cannot afford to go on as you are doing now, sitting still waiting on events, and hoping that something is going to happen. That is the most dangerous and disastrous policy which this country can adopt on this question. [Applause.]

The PRESIDENT: By your applause, you indicate how greatly you appreciate the splendid address that Sir Alfred Mond has been good enough to give us on a subject which is probably the most important that this country has now to consider—namely, unemployment. I will ask the Secretary to read out the names of some of our distinguished visitors, so that members may know who are on the platform, because it is impossible for me to ask each one of them to address you.

Names of Distinguished Visitors and Overseas Members.

The SECRETARY (Mr. Walter T. Dunn, M.I.Mech.E.) read the following list of distinguished visitors and members from overseas:

Sir Alfred Mond, M.P.
Mr. Wm. Woolley, Chairman of the Derby Gas Light and Coke Company.
M. Baril, Société Technique de l'Industrie du Gaz en France.
M. Victor Timmerman, Secretary, Belgian Association of Gas Engineers.
Mr. H. Zollikofer, Secretary, Swiss Association of Gas and Water Engineers.
Mr. John C. Irminger, Bergen, Norway.
Mr. J. G. Tooms, Oslo.
Mr. T. O. Morland, Sydney.
Mr. C. F. Snelgrove, Calcutta.
Mr. Stanley B. Johnson (Colombo).

The PRESIDENT: Mr. Zollikofer will say a word or two on behalf of the foreign delegates.

Mr. H. ZOLLIKOFER: I thank you on behalf of the foreign delegates for your kind invitation to this meeting; and I wish to convey to you their best wishes for the full success of the gathering. I consider it a great honour to the Swiss Association of Gas and Water Engineers that they should have been invited to the annual meeting of your Institution; and I regard it as a privilege, as well as a pleasure, to represent them. Our President desires me to convey to you the expression of his great regret that he should have been prevented from attending this meeting. As delegate of the Society, I should like to present to the Institution of Gas Engineers an expression of the sympathy and friendship of the Swiss Gas Engineers. It will be a pleasure to me to inform our members in Switzerland of the kind reception I have had here. I wish the British gas industry every prosperity and success in its future development. I wish also to express my admiration of the great effort you have made at Wembley, in showing what the gas industry can do over the whole world. My congratulations are offered to you on the great success of this effort.

Good Wishes.

The PRESIDENT: The following telegram has been received from the Société Technique de l'Industrie du Gaz en France:—

> Au nom Société Technique de l' Industrie Gaz en France nous envoyons meilleurs vœux pour pleine réussite votre meeting avec assurance sentiments sympathie cordiale que notre délégué Monsieur Baril vous apportera.—Le Président, ROLLAND D'ESTAPE.
>
> [Translation: The Société Technique sends you best wishes for the complete success of your meeting and assurance of the cordial feeling which our delegate, M. Baril, conveys.]

I now wish to suggest that the Secretary should send a cablegram in the following terms to His Royal Highness the Prince of Wales as an honorary life member of this Institution:—

> The Institution of Gas Engineers, at annual meeting in London, send loyal greetings, and wish you continued success in your tour.—FERGUSON BELL, President.

I am quite sure I shall not have to put this to the meeting; it will receive your unanimous approval. [Applause.]

Confirmation of Minutes.

The PRESIDENT: I now have to move that the minutes of the last meeting be taken as read and confirmed.

Mr. C. F. BOTLEY (Hastings): I have pleasure in seconding that. ["Agreed."]

New Honorary Members.

The PRESIDENT: The next pleasant duty I have to perform is to nominate several gentlemen as honorary members of the Institution. The first name on the list is that of Mr. Charles Hunt, M.Inst.C.E. I have a letter, received yesterday, from Mr. Hunt, in which he says how much he regrets that he is unable to be with us at this meeting; and I am quite sure we equally regret his absence, and hope that he may be speedily restored to health. I am delighted to have on the platform to-day the Lord Mayor of Manchester, Alderman Fred. J. West; and I nominate him as an honorary member. In addition I propose the Presidents of the American, Belgian, Canadian, French, Italian, Norwegian, Swedish, and Swiss Gas Associations as honorary members of the Institution.

Mr. BOTLEY: I scarcely think it needs any words of mine to commend these gentlemen to you. We appreciate very much the association with us of our foreign colleagues. I have very much pleasure in seconding the proposal.

The PRESIDENT: That is carried unanimously, and I will ask Alderman West to reply on behalf of the honorary members.

Alderman FRED. J. WEST: I find it difficult to choose suitable words in which to express my appreciation of the

great honour that has been conferred upon me by the Institution. I can well believe that in taking this step you desire to reflect in some way the great esteem and regard you had for my father ["Hear, hear"], who, as many of you know, was a Past-President of the old Gas Institute, and to whom you awarded the Gold Medal in 1918. I am also conscious of the fact that in my election to honorary membership you have been influenced by the importance of the civic position which I occupy at the present time; and I can wholeheartedly say that, at the conclusion of my Lord Mayoralty, nothing will give me greater satisfaction than to reflect upon the notice which has been taken by the gas industry of the civic work which I have been privileged to perform. When I do relinquish my present civic position, it will be as Fred. West that I shall hope to enjoy my honorary membership, and it will be in that capacity that I shall hope to retain the regard and good-fellowship of the members of the Institution and to continue to be of some service to the gas industry—thus marking the great honour you have done me to-day. [Applause.]

Appointment of Scrutineers.

The PRESIDENT: If it is agreeable to the members, I propose that Mr. J. W. Auchterlonie, of Cambridge, and Mr. Robert Watson, of Doncaster, be appointed Scrutineers of the balloting lists. ["Agreed."]

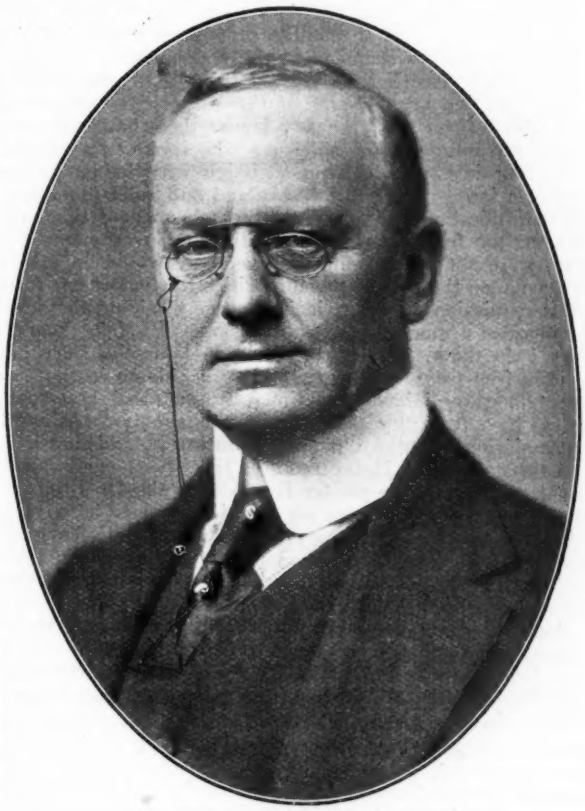
Dr. Carpenter and the Birmingham Medal.

Dr. Charles Carpenter was then invited to step up on to the platform, and was accorded a rousing welcome.

The PRESIDENT: Now a very pleasant duty falls upon me as President, and that is to ask Dr. Charles Carpenter to accept the Birmingham Medal. Your Council unanimously decided that this award should be made to Dr. Carpenter; and it is a source of satisfaction, I am sure, to them, as it is to me, that this decision of the Council has been unanimously agreed to by the Institution. This indicates, I think, a desire on the part of the Institution and of the industry for special recognition to be made of the outstanding services rendered over a long number of years by Dr. Carpenter, who occupies a foremost position in the industry. It affords me considerable pleasure to be the instrument to present the Birmingham Medal to one whose name will add lustre to the list of eminent men to whom the medal has been awarded. The medal was founded in 1881 by the Midland Association of Gas Engineers and Managers, to enable the gas industry to recognize merit and assiduity in connection with the manufacture and application of gas; and I know that I am voicing the opinion of all present when I say that no one has done more to improve the scientific manufacture of gas and its distribution than our good friend Dr. Carpenter, so that the recognition is richly deserved. Though it is 44 years since the Birmingham Medal was instituted, it has only been awarded upon ten occasions, which indicates the jealous care of the Institution in the matter of its bestowal. They are very desirous that it should be awarded to those who not only attain high position, but in other ways merit this distinction for their services to the industry. The first recipient, in 1882, was the late Sir George Livesey, who for many years was the recognized leader of the gas industry, a position which Dr. Carpenter now worthily occupies. As President of the South Metropolitan Gas Company, he has more than maintained the best traditions of that great public utility undertaking. Not only has he done that, but he has always been willing to place at the free disposal of the industry his great abilities and unrivalled technical experience, as well as to render assistance to anyone who may desire it. It is, I am sure, the sincere wish of the gas industry and of this Institution that Dr. Carpenter may be long spared to continue the work in which he is engaged. He is a shining example of what can be accomplished by assiduous industry, fixity of purpose, and capacity to control a large undertaking. I have the greatest pleasure, Dr. Carpenter, in asking you to accept this medal. [Applause.]

Dr. CHARLES CARPENTER: Mr. President and gentlemen, it is very difficult indeed to find words to express the thoughts and emotions with which my heart is charged on this, to me, unique occasion. It has been said that time only approves of those decisions with regard to which time has been consulted; and it is now seventeen years since I relinquished what claim I had (if any) as a justification for the magnificent eulogy which has been pronounced by Mr. Ferguson Bell to-day. It is seventeen years since I relinquished technical control for administration. I have always regarded it as a great sacrifice when I decided upon that change. I will not weary you this morning, because the President has already made one suggestion with reference to brevity, and I should be the last person to desire to transgress it. But by that change, while I have made sacrifices, I have, at any rate, been able to do what otherwise might have been withheld from me. Like your President, I have had before me the goal of the gas industry extended in efficiency and extended in its size. One of the advantages that one has in occupying a position associated with administration rather than the technicalities of gas supply, is that one can look on the various problems involved from a detached point of view; and I have endeavoured during all those years to which I have referred to take, as far as possible, full advantage of that fact. Unfortunately I have in many respects been limited. An all-important one has been the amount of energy I have been able to put into my work, and that seems to be a reducing rather than an increasing quantity.

There is one matter to which I would ask you, as engineers, specially to give your attention; and I was particularly reminded of it when I heard our friend the Lord



THE NEW BIRMINGHAM MEDALLIST.

Previous Recipients: 1882, Sir George Livesey; 1884, Frederick Siemens; 1886, Charles Hunt; 1890, Thomas Newbigging; 1892, Sir W. H. Perkin; 1894, William A. Valon; 1897, Baron von Welsbach; 1905, James W. Helps; 1913, Sir Corbet Woodall; 1918, John West.

Mayor of Manchester refer to the respect and admiration with which the gas industry regarded the work and the career of his great father. The matter I have in mind is the carbonization of coal. In the past, this has been too often looked upon as a process for the handling of raw material and its products. I feel sorely tempted to take up your time this morning by a more extended reference to that than I have now decided upon; and it would perhaps be wrong not to take this chance of saying two or three words with regard to that story. We turn back to those early days when the late Mr. John West was a pioneer in the endeavours to reduce or to eliminate the heavy, arduous work commonly carried out in the retort houses in those days, and we remember how his association with a gas undertaking as its manager and engineer gave him the opportunity of putting these ideas into practice. Now I venture to urge that this moral is a very important one. I see, I think, to-day too great a tendency on the part of the

industry to leave the development of the industry to outside sources, rather than take its problems in hand itself. I quite agree we want all the help possible from outside; but I think it is very important that we should not disregard our own duties as gas engineers in connection with the development of our industry as well. I heard, to my great surprise, the other day of a large undertaking that does not employ its own retort setters or bricklayers. Having regard to the important part played by the construction of the retort house in the economy and working of an undertaking, it does seem an extraordinary thing to me that this very essential part of the work of the concern should be placed in outside hands. I think the industry itself should develop itself, and I take the case of Mr. John West as an example of what has been done in that respect. His hand machines he developed at Maidstone, and then put power to them—I think at first compressed air. Then he built larger machines, operated by means of a steam boiler attached to each. For that he substituted the motive power of a steam or gas engine operating through the medium of a wire rope; and finally he went in for the use of compressed air for conveying energy from the engine room to the retort house.

One other matter on which I should like to say a word has reference to the complaints to-day on the part of the gas industry as to the undue preference which is being given by the Government to the transmission of energy by means of electricity. Well, I think that arises from a misconception on the part of the authorities. We must not blame them, because very few of them have the enormous advantage of the able man who spoke so admirably this morning, of a close association with industry—and with an industry which has a sound and solid foundation of scientific knowledge. Unfortunately men of that type are far too few in connection with our Governments. If that were not so, I cannot believe there would be such a tendency on the part of the authorities to support one form of transmission of energy in preference to aiding the development of a much more important one. ["Hear, hear."] But I do think, gentlemen, that you yourselves are not wholly free from, I was going to say, blame in that respect, because I have sometimes thought that you yourselves have forgotten that electricity is simply a means of transmission of energy, not of producing it, and that it is not the only one. If one requires to convert energy into rapid rotative force—as, for instance, in the De Brouwer charger—one can imagine an electric motor to be a very admirable piece of mechanism to do it; but for discharging a retort, what can be more simple than a hydraulic tube with a ram, into which you turn on, or from which you exhaust, water, as the case may be?

Some time ago I had an application from a firm to be allowed to quote for the large generating station which they felt sure we wanted in a large works like those at East Greenwich. I told them that neither at East Greenwich nor any other works of the Company had we got an electricity generating station at all; and it might have been suggested, as the result of this, that we got our electrical energy from some local authority. If I may take a few more minutes, I should like to tell you a little story, because it does point a moral with regard to this particular point. We have got an undertaking—one of the municipal undertakings I have referred to—which for 25 years has been doing its best to take the bread and butter out of our mouths, and it has been subsidized during most of that time by assistance from the rates. To-day it is in the fortunate position of being able to make both ends meet. But what has contributed to this result? It is the fact that a neighbouring gas undertaking, not content with being able to make its own "juice" by gas engines—as was pointed out many years ago by Mr. Denny Lane, although he was a nationalist—and not content with being able to do it by waste-heat boilers, took electrical energy from the municipal electricity department. Now, gentlemen, in face of these facts, I do think that in the matter of the transmission of power and the generation of power through the medium of the electric generator, some of you might, perhaps, look a little at home. I must not take up any more of your time except to thank you very heartily for the great honour you have done me. I know most of the gentlemen who have received this honour, from my friend Sir George Livesey—whom we all admired—down to the most recent, our friend Mr. Doig Gibb, for whom nothing golden is too good. I rejoice to think that to that number of distinguished gentlemen you have to-day been so good as to add my name.

Mr. GEORGE HELPS (Nuneaton): I wish publicly to congratulate Dr. Carpenter, from the other end of the industry, on being the recipient of this medal.

[Mr. Helps was continuing to speak, when the President asked him to sit down.]

London Gold Medal.

The PRESIDENT: I will now ask Mr. Gibson to come forward. Mr. Gibson, it affords me the greatest possible pleasure to ask your acceptance of this London Gold Medal for your capable paper on "The Construction of New Coal Gas Works at Garston, Liverpool." Since you read that paper, by your courtesy I have been able to see these works; and I can only say that all that was stated in your paper is more than justified. The Liverpool Gas Company are to be congratulated on having an Engineer who is able to construct so admirable a works. I am sure we all congratulate you; and it is with the greatest possible pleasure that I ask you to accept this Gold Medal.

Mr. R. E. GIBSON: I appreciate very much the honour you have conferred upon me in presenting me with the H. E. Jones Gold Medal for my paper last year; and I thank you, Mr. President, for the kind, and too generous, words you have spoken in making the presentation. Naturally it is to me a pleasure and a satisfaction that the paper I read was deemed worthy of this distinction, and I shall regard this Medal as one of my most valued possessions.

The Diplomas.

The PRESIDENT: The Secretary will now read the list of Diplomas in Gas Engineering awarded in 1925 under the Institution's Education Scheme.

The SECRETARY read the names as follows:

First Class.

Thomas Harold Prater, Southgate.

Second Class.

Charles Bateman, Cardiff.
Thomas Vincent Blake, Cardiff.
Thomas Dyson, Huddersfield.
Duncan Dewar Melvin, Glasgow.
Sydney Smith, Birkenhead.

The Diplomas were then presented by the President.

Lord Moulton Memorial.

The PRESIDENT: It is my pleasure now to propose that a sum of £100 be voted by the Institution as a donation to the Lord Moulton Memorial Fund. It will require few words of mine to commend this to your unanimous acceptation. We know that Lord Moulton, who was President of this Institution, was a great scientist, and did great work during the war. He it was who said it was the gas industry, by the contribution of its valuable products, which so materially helped to win the war. We are therefore glad to be associated with this memorial to him; and without further remarks, I will propose the resolution. Mr. Doig Gibb was associated with Lord Moulton, and perhaps he will second it.

Mr. W. DOIG GIBB: I have great pleasure in seconding the proposal. It is up to us to do all the honour we can to the memory of so great a man.

The resolution was heartily agreed to.

The Gas Administrator to the Board of Trade.

The PRESIDENT: We are pleased to have with us now on the platform Mr. H. C. Honey, Director of Gas Administration at the Board of Trade. The work he has done is greatly appreciated by us. We do not always get all we want, but we are satisfied that we get a fair hearing.

The Presidential Address.

The PRESIDENT then delivered his address, which will be found on p. 863.

Dr. CARPENTER: We have had the privilege of listening this morning to two admirable and instructive addresses—each of them dealing with an important national matter; one unemployment and industry, and the other the utilization of our coal resources. As an Institution, we rely year by year upon our Presidents to place before us, and before the public, a vivid and realistic picture of the condition of the industry. That has been done this morning in a manner which compares most favourably with all past attempts in the same direction; and we are very much indebted to our President for the excellent way in which he has outlined what our industry can do for the nation, and emphasized the fact that it provides for the most scientific and the most economic utilization of our coal resources. I have very great pleasure in proposing that the hearty thanks of this meeting of the Institution of Gas Engineers be accorded Mr. Ferguson Bell for the admirable address he has given us this morning.

Mr. HENRY WOODALL: I rise with intense satisfaction to second the proposed vote of thanks to our President for his excellent address; and in doing so I should just like to refer for a moment to one little incident which occurred in 1913. Many of you will remember that in that year Mr. Ferguson Bell, in a very charming and graceful way, retired from the Presidency, which he might have taken, in order that my father, the late Sir Corbet Woodall, might act as President during our Jubilee year. I am sure that many of us very greatly appreciated that action. The next year Dr. Carpenter proposed, and my father seconded, the nomination of Mr. Ferguson Bell to the Presidential Chair; but he, for very good reasons, no doubt, felt unable to take the chair that year. We are only too glad to see that though he could not fill it then, he has been able to do so now. I wish that my father had been here to join again with Dr. Carpenter in appreciation of the services which our President has rendered. Last night I spent with my mother. She remembers with a great deal of pleasure meeting many of you gentlemen; and she said—I do not think it will be out of place, and I hope you will not so regard it—I might tell you that she also remembered Mr. Bell's graceful act, and was very glad to know that he had now become President, and was having such a successful year of office.

Dr. CARPENTER: The resolution is before you, and I will ask you to signify your acceptance of it in the usual cordial fashion.

This having been done,

The PRESIDENT said: I very greatly appreciate the all too flattering remarks that have been made by my friends Dr. Carpenter and Mr. Woodall. It is a great honour to me that the proposer and seconder of this vote of thanks should be gentlemen who are so deservedly respected in the gas industry. With regard to the remarks of the seconder, I am glad to know that Lady Woodall remembers us, and takes a kindly interest in our proceedings. On your behalf I shall ask Mr. Woodall to convey to his mother our thanks for her kind message. I have already spoken for nearly three-quarters of an hour, and will now only express my appreciation and my gratitude for all your kindness, and say again what a pleasure it is to me to be your President. I did not accept the nomination of my good friends Dr. Carpenter and Sir Corbet some twelve years ago, because I had not then the necessary health, and I certainly had not the experience which I have since acquired. Thus I do not think the Institution have lost anything by waiting. It is said that everything comes to him who knows how to wait. I waited; and I thank you now for having elected me President. I hope we shall have a very successful meeting.

Annual Report and Accounts.

[See "JOURNAL" for June 3, p. 662.]

The PRESIDENT: I will now move the adoption of the report of the Council for the year 1924-25, and the statement of accounts for the twelve months ended Dec. 31 last. You have all had the report in your hands for several weeks, and I do not think there is anything in it over which you would desire me to occupy your time.

Mr. J. D. SMITH, J.P. (Belfast): I have much pleasure in seconding that.

The report and accounts were adopted without discussion.

Report of the Advisory Committee on Education.

The PRESIDENT: I will next ask our good friend Mr. F. W. Goodenough, the Chairman of the Advisory Committee on Education, to submit the report of that Committee. We are very much indebted to the Education Committee, and especially to the Chairman, for the great amount of work put into the scheme.

Mr. F. W. Goodenough then presented the report, which, with his statement, will be found on p. 877.

Thirteenth Report of the Investigation Committee.

Prof. J. W. COBB then introduced the Thirteenth Report of the Gas Investigation Committee on "Aeration in Atmospheric Burners, with Special Reference to Lighting Burners." Before doing so, he remarked: In the first place, I may say that I am quite sure you share the regret which is felt by the Research Committee and myself that this report is not introduced by Prof. Smithells, simply and solely because he has been suffering from severe illness—probably the only cause which could have prevented him being present on an occasion of this kind. However, I had a letter only yesterday morning, in which he assures me that his progress towards health and strength is entirely satisfactory. This I have no doubt everybody present will be pleased to hear.

The PRESIDENT: I have a letter from Prof. Smithells in which he says:

> I am writing to say how very sorry I am that I shall not be present at the forthcoming meetings of the Institution. I have got a long way on the path of recovery from my recent troubles; but I am forbidden for a little while yet to attend meetings.
>
> It is a very great disappointment to me that I cannot attend. The programme is most alluring; and it would have been a great pleasure to me to be present to hear your address, to see honour bestowed so worthily on Dr. Carpenter, and to share in what I am sure will be an exceptionally interesting meeting. I need hardly offer my wishes for its success.

I am sure we are all very sorry he is not able to come, but we are delighted to know that he is well on the path to recovery.

Mr. J. W. WOOD summarized the report, which, with Prof. Cobb's introduction, will be found on p. 879.

Fourteenth Report of the Investigation Committee.

Prof. COBB then presented, and Dr. Parker summarized, the Fourteenth Report of the Gas Investigation Committee, on Corbet Woodall Experimental Gas Plant Carbonization Trials at the Leeds University—see p. 898.

Handsome Donation to the Benevolent Fund.

The PRESIDENT: I have a very pleasant message to give you which has just been handed to me. The Lord Mayor of Manchester says: "I propose to contribute £100 towards the Benevolent Fund, which I suggest should be invested so as to bring in an income of £5 per annum." We very much appreciate this kindly thought on the part of one of the latest of our honorary members.

More Good Wishes.

The PRESIDENT: Before we settle down to the afternoon's business, you will be very glad to know of the receipt of a cablegram from Mr. M'Lusky, of Glasgow, who is in America, sending: "Best wishes for a successful meeting."

The Tankless Gasholder.

The PRESIDENT: The first paper on our programme is entitled "The Tankless Gasholder at the Etablissements Arbel, Douai, France," by M. Rolland d'Estape, President of the Société Technique de l'Industrie du Gaz

en France. Unfortunately, M. d'Estape is unable to be here this afternoon; but M. Baril has undertaken to read it for him. We very much appreciate a paper from France on a subject which must be of great interest and importance to all gas engineers.

The paper, with a report of the discussion, will be found on p. 911.

Numerous questions were put to M. Baril, and to them that gentleman replied in French—Mr. Zollikofer kindly undertaking the duty of interpreter.

Carbonizing Plant at Stretford.

The first day's proceedings closed with a paper by Mr. W. M. Carr on "The Selection, Design, and Construction of New Carbonizing Plant at Stretford." This and the discussion appear on p. 915.

The Benevolent Fund.

Wednesday morning's session opened with the Annual General Meeting of the Benevolent Fund (see p. 876).

Additions to the Roll of Members.

The SECRETARY announced the following additions to the membership roll; and those of the newly elected who were present were introduced to the meeting.

MEMBERS.

Anderson, George Edwin, Works Manager, Howdon Works, Newcastle-on-Tyne.
Ashworth, Richard, Engineer, Manager and Secretary, Tamworth Gas-Works.
Atkinson, Richard Littledale, Assistant Manager, Elswick Gas-Works, Newcastle-on-Tyne.
Barnard, Robert Henry, Manager and Secretary, Gas-Works, Wantage.
Beveridge, James Wilson, Engineer and Manager, Gas-Works, Troon, Ayrshire.
Birchmore, Leonard, Engineer and Manager, Louth Gas-Works.
Birks, Falconer Moffat, O.B.E., Mechanical Engineer, Gas-Works, Beckton.
Breaks, Christopher, Engineer and Manager, Ellesmere Port Gas-Works.
Calderwood, Robert John, Gas and Water Engineer and Manager to Spalding U.D.C.
Dean, Harry Watson, Engineer and Manager, Padiham U.D.C. Gas Department.
Dearden, Walter Armitage, Engineer and Manager, Gas Department, Johnstone, Renfrewshire.
Demain, John, Engineer and Manager, Ripon Gas-Works.
Dixon, James Edward, Works Manager, Elswick Gas-Works, Newcastle-on-Tyne.
Greenough, Peter, Gas and Water Engineer, Hindley.
Perks, George Watson, Chief Chemist, Stockton-on-Tees Gas-Works.
Reid, Norman, Manager of Redheugh Gas-Works, Newcastle-on-Tyne.
Robertshaw, Walter Livesey, Works Manager of the Ayre's Quay Works of the Sunderland Gas Company.
Sahlberg, Hans Ferdinard, Director of the Helsingfors Municipal Gas-Works.
Sato, Kenji, Manager of the Omori Gas-Works of the Tokio Gas Company.
Surtees, Gilbert, Engineer and Manager, Uttoxeter Gas-Works.
Watson, Alfred Thomas, Engineer and Manager, Rushden and Higham Ferrers District Gas-Works.
Whatley, Greville John, Assistant to F. H. Jones, Consulting Gas Engineer, London.

ASSOCIATE MEMBERS.

Alexander, Anthony Parker, Engineering Assistant at South Bank Gas-Works.
Bell, William, Second Assistant to Engineer and Manager, Reading Gas Company.
*Bengough, Francis John, Junior Engineer, Nechells Works, Birmingham Gas Department.
Birch, Ernest, Assistant Distribution Superintendent, Stockton-on-Tees Gas Department.
*Carmichael, Stanley, Works Chemist, Avon Street Gas-Works, Bristol.
Cleator, James Radcliffe, Senior Assistant, South Bank Gas-Works.
*Cowles, Harold Austin, Coal Test Works Shift Chemist, Nechells Works, Birmingham Gas Department.
Cox, Spencer H., Assistant Works Manager, Haywards Heath District Gas Company.
*Dupont, Fernand, Chief Assistant Engineer, Neath Gas Department.
Ely, Robert John, Assistant Manager to the Ridding District Gas Company.
Fall, Frederick Percy, Engineering Assistant and Chief Draughtsman, Sunderland Gas Company.
Hart, Edward Holford, Works Chemist, Romford Gas and Coke Company.
Kimpster, William Corbitt, Technical Assistant, Newcastle and Gateshead Gas Company.
*Mortimer, Thomas Rayner, Assistant Engineer and Manager, Brighouse Gas Department.
Nicholls, Frederick, Chemist, Redheugh Gas-Works, Newcastle-on-Tyne.
*Parrett, Jack, Technical Assistant, Exeter Gas Light and Coke Company.
*Prater, Thomas Harold, Chemist to the Tottenham and District Light, Heat, and Power Company.
*Preston, Joe Bray, Technical Assistant, Spenborough Urban District Council Gas Department.
Rioch, John Hunter, Assistant Engineer, and Manager, Gas Department, Inverness.
Robson, Colin, Technical and Chemist Assistant, Elswick Gas-Works, Newcastle and Gateshead Gas Company.
Sheehan, Patrick Joseph, Assistant Engineer, Cork Gas-Works.
Summerson, Roy, Chief Chemist and Junior Assistant at the Gas-Works, Luton.
Williams, Samuel James Downing, Assistant Engineer, Gas-Works, Stourbridge.
*Winch, Egbert Harold, Second Assistant, Cambridge University and Town Gas Light Company.
Woodfine, Cecil Hadlow, Works Chemist and Technical Assistant, Gas-Works, Wellington, Salop.

ASSOCIATES.

*Clark, Herbert Patrick, Gas Examiner for East Ham, Barking, and part of Essex.
Fleminger, Sidney, F.C.S., Official Gas Examiner and Consulting Chemist, London.
Townend, Frank Sutcliffe, B.Sc. (Eng.), Assistant to Dr. E. W. Smith, Technical Director of the Woodall-Duckham Companies, London.

The PRESIDENT: The Institution is progressing as far as numbers are concerned.

More Telegrams.

The PRESIDENT: I have received a telegram this morning from the Italian Association of Gas Engineers, sending salutations and best wishes to their English colleagues. I have also received a message from the Mayor of Derby, regretting that, owing to civic and other duties, he is unable to be with us.

A Member for Derby.

The PRESIDENT: I now have the greatest pleasure in introducing to you Sir Richard Luce, one of the Members of Parliament for Derby; and I take it as a personal compliment that he has come here. When I tell you he was in the House of Commons until 4 o'clock this morning, I think it shows a great example. We are very delighted to have Sir Richard with us, not only because he is an eminent Member of Parliament, but because—and this may appeal more to you—he is a very eminent surgeon. I will ask him to say a few words.

Sir RICHARD LUCE: I take it as a great honour that you should have asked me to come here to-day. May I also say that I consider it a great honour to Derby that you should have elected my fellow townsman, Mr. Ferguson Bell, as the President of your Institution for this year? I am very happy to be associated with you to-day in supporting him on this great occasion, and wish you every success in your meetings.

Wrought-Iron Tubing Committee.

After Mr. W. M. Carr had replied to the discussion on his paper, which had taken place on Tuesday afternoon, the report of the Wrought-Iron Tubing Committee was submitted by Mr. R. H. Ruthven, Hon. Secretary of the Committee. See notice on p. 932.

International Commission on Illumination.

Mr. ROBERT WATSON, of Doncaster (delegate of the Institution), presented the report of the sixth meeting of the International Commission on Illumination. See notice on p. 932.

Joint Refractories Research Committee.

The report of the Joint Refractories Research Committee was next taken. It was presented by Mr. J. P. Leather, the Chairman of the Committee. See p. 932.

Developments in Gas Calorimetry.

Prof. C. V. BOYS, F.R.S. (one of the Gas Referees), read a paper entitled "Developments in Gas Calorimetry;" and this, together with the discussion, is reproduced on p. 933.

Institution Gas Research Fellowship.

Prof. COBB introduced the report of the Institution Gas Research Fellowship on "The Influence of the Inorganic Constituents of Coal in Carbonization and Gasification, with Special Reference to Nitrogen and Sulphur," by Mr. C. B. Marson, B.Sc. (Institution Gas Research Fellow), and Prof. J. W. Cobb, C.B.E., B.Sc., F.I.C. (Livesey Professor). See p. 932.

Town Gas for Motive Power.

On the resumption of the proceedings on Thursday morning, Sir Dugald Clerk, K.B.E., F.R.S., read a paper on "Town Gas for Motive Power." This and the discussion are given on p. 939.

The PRESIDENT: I have the pleasant duty of asking Sir Dugald Clerk to give this communication. Sir Dugald Clerk requires no introduction to any Institution in London, much less to the gentlemen whom I see before me, and I am quite sure that you will be delighted that he is able to come here and read a paper.

Economics of Gas Production on the Thermal Basis.

The final paper of the meeting was by Mr. George Evetts, and was entitled "The Economics of Gas Production on the Thermal Basis." This with the discussion will be found on p. 943.

The Balloting List.

The PRESIDENT: I have now to announce the result of the balloting. You will be glad to know that Mr. Botley has been unanimously elected President of our Institution. [Applause.] On your behalf, I offer to Mr. Botley sincere congratulations, and feel sure he will receive the full support, not only of the Council, but of all the members of the Institution. We hope that he will have a very successful and very pleasant year of office. The two Vice-Presidents are my friend Mr. Wilkinson, who resides not far away from Derby; as he comes from the Midlands, we know he is a good man. The other is Mr. Madden, who has been prominently connected with the Institution. He has taken a very active part in the proceedings, and I am sure we are all very pleased to know that he has agreed to become Junior Vice-President. For Auditors, we have our good friend Mr. Shoubridge, and Messrs. Wood, Drew, & Co. The Hon. Secretary, as you will all fully expect, is another old friend, Mr. Price. Mr. Price is invaluable. He tells the President what to do, and the President does it. The ordinary members of Council are Messrs. Armitage, Bennett, Copp, and Langford. We had a very good list of nominations. It took me a long time to decide for whom I should vote. In fact, I should have liked to vote for them all, because they would have made excellent members of Council. However, those who have not been elected I hope will allow their names to go forward on a future occasion, when they will doubtless be elected. I call upon our new President, Mr. Botley.

The New President.

Mr. C. F. BOTLEY (Hastings): Mr. President and gentlemen, it is perhaps difficult in a few words to express one's feelings on an occasion like this; but I would first of all like to express a sense of the honour that I realize has been done me by those who in the first instance thought fit to nominate me, and now by you who have seen your way to support that nomination. Remembering that it has been my great privilege to work with my friend Mr. Bell and other of the Immediate Past-Presidents, I shall have some trepidation in endeavouring to emulate the work they have so splendidly done. But with your support—and without that, of course, it would be quite impossible to be a worthy President of the Institution—and the support of the Council, of which I am assured, I will strive to the utmost of my ability to uphold the high traditions and the great usefulness of the Institution.

List of New Officers.

President.—Mr. Charles F. Botley, of Hastings.
Senior Vice-President.—Mr. John Wilkinson, of Nottingham.
Junior Vice-President.—Mr. Henry D. Madden, of Cardiff.
Auditors.—Mr. Sydney Y. Shoubridge, of Eastbourne, and Messrs. Wood, Drew, & Co., of London.
Hon. Secretary.—Mr. W. E. Price, of West Chobham.
Ordinary Members of Council.—Messrs. Leonard J. Langford, of Tunbridge Wells; Harold E. Copp, of Hull; William H. Bennett, of Redhill; and Mr. Cecil Rhodes Armitage, of London.

Presidential Certificate.

Mr. BOTLEY: I am not President yet; but by virtue of my office as Senior Vice-President, I have—it is the usual procedure—now to perform one of the pleasant duties which fall to the holder of the office. That is to put before the meeting in the best way I can an expression of our thanks to Mr. Bell, our President. [Applause.] Having had the great pleasure of being associated with my old friend Mr. Bell as one of the Vice-Presidents, I have had the opportunity of seeing from behind the scenes what our President has done; and I am sure that I am voicing the views of all of you when I say that he has fulfilled the expectations of those of you who know him. When Mr. Ferguson Bell some years ago stood aside, as was so very gracefully acknowledged by Mr. Henry Woodall at our opening session, in order that we might have the benefit of the services of the late Sir Corbet Woodall, he did so very willingly; and, as he himself has pointed out, the Institution have possibly been the gainers. We have had from him the benefit of extended experience, and he has perhaps been able to do for us what he could not have done years ago. We have had a most successful meeting; and I can assure you that, whatever help he has had—and of course Mr. Price, and the Secretary, and the members of Council have loyally rendered assistance to him—the initiation of practically everything has been due to the President. You know how he has drawn upon his knowledge of facts and people, and has secured at this meeting the attendance of distinguished guests. We have, I believe, derived a very great and lasting benefit from this meeting. But we are indebted to our President not only from the point of view of the gas industry; we must not forget the social side. As one who participated in that most enjoyable function last Tuesday, I must say that we owe Mr. Bell, Mrs. Bell, and their daughters very many thanks; and those of you who are going to Derby have a rich treat in store. Our President has rendered to the town of Derby and to the Company with which he is connected invaluable services; and I was very pleased to find that one, at any rate, of the Members of Parliament for Derby is of the same opinion. Doubtless both of them are; but I only heard one of them actually speaking. We are looking forward to a great day at Derby, and to the opportunity of congratulating our President there upon his actual work in his own town.

Before I sit down, I have another very pleasant duty to fulfil on your behalf. You know that it has within the last year or two been decided that there shall be given to the President a certificate, recording the fact that he has served the Institution in that capacity. No one, I venture to say, occupies the Presidential Chair without having a lasting recollection of the duties and pleasures which appertain to the office. But, Sir, there are those who come after us; and it is probably gratifying to our friends to have something tangible to remind them that we have done certain things. Memory, after all, is very short-lived. We pass away, and what we have done is apt to be very soon forgotten. Therefore it is very proper that there should be something to show that we have at some time or other been deemed worthy to be put at the head of the profession to which we belong. I have the greatest pleasure in asking you, Sir, to accept this certificate, and in addition I tender you our heartiest thanks for the invaluable services you have rendered to the industry and to us during the past year. It is not necessary for that to be seconded. [Applause.]

The PRESIDENT: I do very sincerely thank Mr. Botley for his altogether too flattering remarks with reference to

the services that I have been permitted to perform. My year of office has been an extremely pleasant one, and I have made a host of friends. I am delighted with the certificate, which shall be hung up in my study, to remind me of a very happy year. My wife is extremely pleased to know that our social function was a success, and she is looking forward to seeing at Derby a great number of you, accompanied by your ladies. I have received at the hands of the Council the fullest support, and also extreme kindness from the members of the Institution. This Institution, as is the case with similar bodies, depends very much upon what the members put into it; and the members during the past year have put a good deal of work into the Institution. This accounts, no doubt, for the success of our annual meeting. I can assure Mr. Botley he need have no fears in taking on the Presidency—he will receive the whole-hearted support, not only of the members of the Council, but of the entire Institution. I thank you most cordially for the kind way in which you have treated me during my year of office. If I have fulfilled your expectations, I am amply repaid.

Votes of Thanks.

The President: Before we separate, I should like to propose that the best thanks of the Institution be given to the Institution of Civil Engineers for their kindness in granting us the use of their House and this beautiful hall for our meetings. We are very glad indeed to get such excellent accommodation, which conduces greatly to the success of our meetings; and we thank them very sincerely.

Mr. F. P. Tarratt (Newcastle-on-Tyne): I second with pleasure this vote of thanks to the Institution of Civil Engineers. We much appreciate the kindness that they have extended to us.

Mr. John Wilkinson (Nottingham): I propose that the best thanks of this meeting be accorded to the Chairman and Directors of the Derby Gas Light and Coke Company for their invitation to visit the town, and for the hospitable arrangements that have been made for members and their ladies. We have seen what the President has done to entertain us here in London; and I am quite sure his Chairman and Directors will not be behind him.

Mr. H. D. Madden (Cardiff): It is a great pleasure to second that resolution. I think we are already indebted to the Chairman and Directors of the Derby Gas Company, for I feel sure that Mr. Bell has been backed-up by them handsomely during his year of office—which will certainly do a tremendous lot of good for the gas industry. Excellent propaganda work has been done.

The President: On behalf of the Chairman and Directors of the Derby Gas Company, whom it is my privilege to serve, I thank you very much for this vote, which shall be conveyed to the Board, who have been very kind to me during the past year. They told me when I became President of the Institution I was quite free to attend meetings in London and other places. They have, in fact, taken a lively interest in everything that affects the Institution. I am very glad that you have passed this vote, because at Derby the time will be fully occupied. We thought you would prefer to see the beauties of Derbyshire rather than to go through a toast list at the luncheon.

Mr. W. J. Smith (Bolton): It is my privilege to propose a vote of thanks to the National Physical Laboratory, the Gas Light and Coke Company, and the South Metropolitan Gas Company, for the very excellent arrangements made by them for the entertainment of the members of the Institution this afternoon.

Mr. W. S. Morland (Gloucester): I have pleasure in seconding that.

The President: There is another vote of thanks that I should like to propose. That is to Sir Henry Fowler, who used to be a member of this Institution, and is now Locomotive Superintendent to the L.M. & S. Railway. He was here yesterday, and you will see him again to-morrow at Derby. I know he is looking forward to renewing many old friendships, and he will show you an interesting locomotive works. I would also include the Carriage and Wagon Works of the L.M. & S. Railway, where you will see most ingenious labour-saving devices, and the Royal Crown Porcelain Works, to which the ladies are going.

Mr. Hubert Pooley (Leicester): I will second that, for I am quite certain we are going to have a most interesting day to-morrow.

Mr. C. Diamond (Barrow-in-Furness): As one of the younger members of the Institution, I deem it an honour to propose a vote of thanks to the Council, the Hon. Secretary, the authors of papers, the Research Committees, the Scrutineers, and the Auditors. It needs no words of mine to extol their labours.

Mr. J. H. Canning (Newport): It is a pleasure to me to second that, for I am sure a vote of thanks is due to those gentlemen who have co-operated with our President so excellently in making this meeting an unqualified success.

The President: I feel I must say how much I am indebted to Mr. Price, and to our Secretary, Mr. Dunn. Mr. Dunn has been laid-up for perhaps a fortnight; but he has been incessantly working at home, and the staff have helped me greatly. I have been in constant communication with Mr. Dunn all through the year, and have always found him most zealous and anxious to promote the welfare of the Institution in every possible way. I believe he has been our Secretary for about thirty years; and the arrangements he has made on all occasions have amply proved his capacity.

Mr. Wilkinson: The vote is an omnibus one, and, on behalf of the passengers travelling inside that omnibus, I thank you heartily for your kind expression of appreciation of the efforts that have been made on your behalf.

Mr. Price: I am much obliged to you for again electing me your Hon. Secretary; and while you do that I will do my best to give advice and guidance, if necessary, to the gentleman who happens to be the President for the time being. Your selection of President is, however, so excellent that really I find that the material I have to handle has already been modelled in a most proper manner, and all that I have to do is to see that it does not fall to pieces. [Laughter.]

Mr. Walter Dunn: I feel very much touched by what the President has said. I appreciate it immensely, and I am proud of being Secretary. I hope that I may continue to give the Institution satisfaction in that capacity. In the "Gas Journal," Mr. Bezant (the Editor) has been digging up old history; and I find that I am thirty years older than I was when I became your Secretary. We are, however, all growing older together; so I do not mind. I am a Scout Master, and am proud of it; and I think that helps to keep me young. Those who understand what a pleasure it is to see one's work succeed will understand my feelings when I tell you how proud I am to see our Institution flourish. Everyone connected with the Institution helps me; I could not do it alone. I make suggestions which are sometimes turned down and sometimes turned up, and become trumps. I have a suggestion for the new President, which I hope will mature.

Next Year's Meeting.

Mr. Botley: There is just one other subject I should like to refer to before the meeting disperses. I should not wish to be absolutely committal on the matter to-day; but there is just a possibility that the meeting could be held in Hastings next year. Nothing must, however, be done which would in any way interfere with the convenience of the members or the successful working of the Institution; and I should like, with the President's permission, to get some indication of the feeling of the meeting on the matter. Of course, if the meeting were held in London, there would be a possibility of an excursion to Hastings. Will somebody make a proposition? Well, as there seems to be no decided feeling on the matter one way or the other, you will have to leave it to the Council and myself to decide.

The President: That, gentlemen, concludes our business.

THE PRESIDENTIAL ADDRESS

OF

Mr. J. FERGUSON BELL, M.Inst.C.E., M.I.Mech.E.

General Manager and Engineer of the Derby Gas Light and Coke Company.

This being the first occasion on which it is my privilege to meet you collectively as President, I desire to take the opportunity to express my sincere thanks for the honour you have conferred upon me. The election to this Chair is the highest distinction which the Institution can bestow on those who have endeavoured to serve it faithfully and well. This Institution has attained to such a position that to be its President is to enjoy an honour which it is impossible to regard lightly; and I solicit the continued enthusiastic activity of members to promote the advancement of our industry by applying themselves to the solution of the many problems on which success depends. A year ago the Institution was 1005 strong; to-day we number about 1100. This indicates we are a growing body, representing a rapidly growing industry, with immense potentialities for the benefit of the community.

Honorary Members.

The honorary members number 21, a notable addition during the year being H.R.H. the Prince of Wales, who graciously consented to become an honorary life member. The Institution, as the technical head of the gas industry, is proud of this Royal recognition of service rendered to the community by one of the most important of our public utility services.

In addition, the proposed transfer of Mr. Charles Hunt—now the doyen of the gas industry—to honorary membership will, I feel sure, receive your hearty approval. Mr. Hunt for many years has been a distinguished member, and as an engineer, administrator, and adviser has won a prominent position. This transfer is to mark our recognition of his many valued services.

It was intended to confer a similar honour on one who for half-a-century was an outstanding and striking personality in the profession. I refer to the late Mr. H. E. Jones, who, as Chairman and Director of many gas companies, both at home and abroad, did invaluable service for the industry. The name of H. E. Jones will be long remembered as the donor of the "London" gold medal—shortly before his death he transferred securities to this Institution to provide for a gold medal to be presented annually.

Another name well known and deservedly respected is that of Alderman F. J. West, the present Lord Mayor of Manchester, who has done much to advance the scientific carbonization of coal. For many years the name of West has been a household word in the gas industry; and your Council decided to nominate Alderman F. J. West as an honorary member of the Institution—a course which I know the members will approve.

Institution Activities.

The activities of the Institution are indicated by our annual "Transactions," and by the proceedings of the Council as reported from time to time in the Technical Press. They indicate steady progress, as the result of our deliberations and specialized investigations in conjunction with other organizations for co-ordination of scientific and industrial research, also independent investigations of essential problems to bring about a greater interfusion of theoretical scientific information and practical knowledge as to the best and most effective methods to elucidate those problems peculiar to our specialized industry.

Scientific research is the main, if not the only, source of fresh productivity in industry; and it is only by increased productivity that this country will find a way out of its present economic difficulties.

Education.

Our industry is of such a technical character that well-trained skilled technicians are absolutely necessary if we are to continue to carry on successfully the work which, year by year, becomes more important, as the figures I am about to give you conclusively prove.

Your Council for some time have had under consideration an Education Scheme, whereby those engaged in the industry will be afforded increased opportunities to equip themselves more thoroughly for their work. It has been approved by the Board of Education and City and Guilds of London Institute. Also I am happy to state it will generally receive the support of Local Education Authorities.

The Institution Education Syllabus has recently been issued. I commend this step, which may eventually be one of far-reaching importance, and ask your active co-operation towards making it a success. It is probable that membership of this Institution will, in the near future, be by examination. There are already 23 Technical Colleges giving "Course" instructions under the scheme. The number of students applying for examination shows a gratifying increase, being almost double that of the previous year. The Committee are to be congratulated upon the success that has attended their efforts, upon which they have spent much time and thought.

Importance of the Gas Industry.

The magnitude of our industry is indicated by the latest available Board of Trade returns relating to all authorized gas undertakings in Great Britain (for the year 1923) There are 790 company and local authorities' undertakings; the summary relating thereto is as follows:

Total coal, C.W.G., and other gas, millions c.ft.		259,819½
Coal gas made, millions c.ft.		217,756¾
C.W.G. or blue gas made, millions c.ft.		38,347½
Coke oven and other gas, millions c.ft.		3,745¼
Coal carbonized, tons		16,460,632
Coke used for C.W.G., tons		906,717
Oil used for C.W.G., galls.		42,751,644
Coke and breeze made, tons		11,098,169
Tar made, galls.		181,962,574
Sulphate of ammonia made, tons		117,166
Consumers—Prepayment	4,231,243	
Ordinary	3,579,107	
		7,810,350
Length of gas mains, miles		40,984¼

The total nominal capital invested in the undertakings dealt with in this return is £165,210,254 (including loans raised by local authorities and sums repaid), an increase of £2,281,229 over the previous year. The receipts of the undertakings on revenue account amount to £67,576,358, and the expenditure to £56,593,900, which includes some 2½ million pounds for local rates—leaving a gross profit of £10,982,458—£444,758 less than in 1922, due mainly to the lower prices charged for gas. The recent slump in prices of all residual products will unfortunately mean an increase this year in the price of gas in most places.

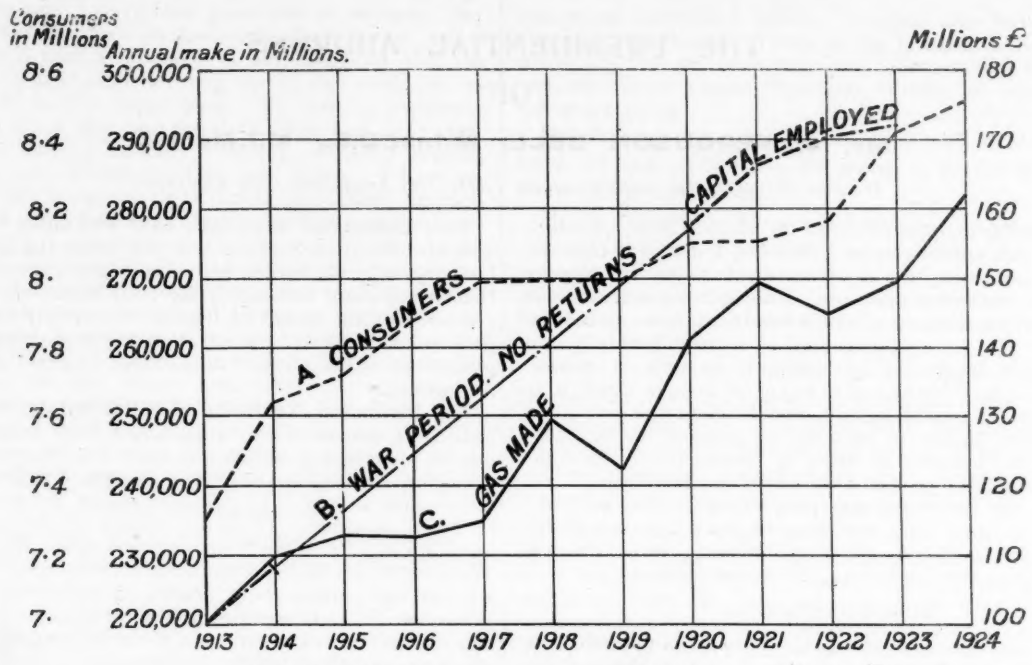
Striking Progress.

The striking progress of the gas industry in the United Kingdom since 1913 is shown by the diagram (Fig. 1) of statutory and non-statutory undertakings, giving the estimated total quantity in millions of cubic feet of gas made, number of consumers in millions, and capital employed in millions of pounds sterling.

It will be seen from the diagram that in the last five years the output has increased from 242 thousand million to 282 thousand million c.ft., an increase of no less than 40 thousand million c.ft., or more than the total gas made by the Gas Light and Coke Company, which is by far the largest gas undertaking in the world. Incidentally, it is interesting to record the fact that the Gas Light and Coke Company alone supplies more heat units than the combined output of all the electricity undertakings in this country.

The number of consumers has increased from about 8 millions to over 8½ millions. This increase alone is equal to the total population of two large cities such as Nottingham and Leicester.

The capital employed in the last three years has increased from £156,869,911 in 1920 to £173,470,766



CURVE A. Number of Consumers in Millions.

CURVE B. Total Share & Loan Capital employed in Millions of £.

CURVE C. Annual makes of Gas in Millions of Cubic Feet.

FIG. 1.—STATUTORY AND NON-STATUTORY UNDERTAKINGS, 1913-24.

in 1923. This is a growth of £16,600,855, or an average increase of just over £5,533,618 per annum.

This remarkable progress conclusively indicates that town gas in Great Britain is being used in an increasing quantity by an increasing number of consumers.

The Position in the United States.

The President of the American Gas Association has been kind enough to send me information as to the position of the gas industry in America. In 1903 the sales of manufactured gas totalled 105½ thousand million c.ft., and 124 thousand million c.ft. of natural gas; and in 1923 a new high record was reached of 370 thousand million c.ft. of manufactured gas and 760 thousand million c.ft. of natural gas. Thus in twenty years the sale of manufactured and natural gas in America reached the huge figure of 1130 thousand millions of c.ft., or about four times the make of the whole of the 790 authorized gas undertakings in Great Britain for the year 1923.

In certain districts in the United States natural gas is giving out; but its use in large quantities has so accustomed consumers to the many advantages and economies attending gaseous fuel that they will not return to solid fuel. There are 9½ million consumers, and new ones are being added in the United States at the rate of more than 400,000 a year. A notable fact is that, of the 964 undertakings, only 51 are operated by municipal authorities. A great expansion in auxiliary house heating by gas is taking place, and companies are putting in house-heating installations at the rate of about 10,000 a year. In some sections of the country they are supplying a large number of gas refrigeration machine installations. Annual sales of gas appliances aggregate 750,000 cooking stoves, 425,000 water heaters and 400,000 gas fires.

One of the principal factors responsible for the greatly increased sale of gas in America is the growing demand for gas in industry, where, according to the American Gas Association, gas is now used in more than 5000 separate and distinct ways. There was an increased consumption during the last decade of more than double, while its use for industrial purposes increased about 1000 p.ct.

In order to keep up with the demands by consumers, the gas companies spent $450,000,000 during 1923 on new works; and reports filed with the American Gas Association by its members show that the industry is enjoying the greatest expansion in its history. The results for 1924 are not yet available, but they are expected to show a large increase over the previous year. This is in a country with an abundance of natural water power, which has been called "white coal," rendering the generation of electricity in large quantities comparatively easy and inexpensive.

Cheap and Ample Supplies of Heat Energy.

Statistics are wearisome. I have quoted sufficient to indicate the importance and magnitude of the gas industry in this country and abroad. Contrary to the opinion of those unacquainted with the facts, its greatest growth has occurred during the past twenty years. Instead of declining in importance, it is now on the eve of its greatest expansion—given the same consideration as its competitors. The benefits that can be derived from one of the most important key industries in the country are being realized—whereby a substantial increase is obtained in the availability of the potential heat units of the coal used, and at the same time recovery of valuable bye-products so necessary to the country in time of peace. Their applicability and vital necessity were demonstrated in a remarkable manner during the war.

The provision of cheap and ample supplies of heat energy in the form of gaseous fuel can be best and most economically provided by the gas industry. In this connection, it is also a remarkable sign of the times that the British Commercial Gas Association have now on record a list of over 4000 trades in which gas is used, with an average of seven processes to each trade. This indicates the immense field there is for future development.

The gas industry has become one of the greatest co-operative efforts in the world. Through the National Gas Council, representing 841 company and municipal undertakings, being 88 p.ct. of the total make of gas in the United Kingdom, the industry has combined its forces for the benefit of consumers, employees, and producers, very ably guided by Mr. Milne Watson, D.L., the Governor of the Gas Light and Coke Company, assisted by an efficient staff.

Coal Conservation.

The importance of a more efficient utilization of our coal supplies, which are the foundation of this country's industrial position, demands that more attention should be given to this subject. Our national fuel resources are by no means inexhaustible. They are diminishing; yet our wealth of coal is being recklessly squandered in many directions.

The burning of raw coal in furnaces and open grates is extremely wasteful, resulting in unnecessary reduction in

our national coal resources, and also additional loss to the country by non-recovery of valuable bye-products, so essential for many industries. The baneful effect of smoke in most industrial centres is evident from the disfiguring effects, resulting in the drab and sordid appearance of many of our towns, and also in a reduction of available sunlight and ultra-violet rays, which not only adversely affects health, but involves an appreciable annual expenditure in making good the damage to buildings, &c.

The combination kitchen range for use simultaneously for heating, cooking, and hot-water supply is excessively extravagant in fuel and inefficient as compared with separate appliances designed for the special purposes. For instance, a coke-fired hot-water boiler uses only one-quarter of the fuel required by a range boiler. The combination of several functions in one range renders each separate function wasteful when used alone; and in ordinary practice they are not simultaneously required. For cooking and heating, gaseous fuel, used in properly designed appliances, effects a big saving in fuel and labour, with convenience and economy. The existing enactments are not sufficiently drastic to ensure even the curtailment of the evils arising from coal smoke and invisible sulphurous acid pollution. The time has arrived when the use of smoky fuel should be prohibited by legislation in the interest of health and to conserve our coal supplies.

The more extended use of gaseous fuel for trade and domestic purposes means a substantial increase in thermal efficiency, abating the smoke nuisance, and promoting better health, comfort, and convenience, less labour, and improved amenities of our towns. It is estimated that the extra cost for fuel and washing materials attributable to the smoky atmosphere in many industrial areas is equal to 7½d. per week per household, which for a town of a quarter-of-a-million inhabitants means a loss of over £100,000 per annum—and this without taking into account the contributory cause of general ill-health and squalid appearance of those smoke-laden districts.

Nowhere is coal treated with the same over-all efficiency as in the principal gas-works of this country; the thermal efficiency being well over 70 p.ct.

The total coal mined in the United Kingdom during 1923 was about 250 million tons. Some 186 million tons, or 75 p.ct., was for home requirements, of which 38 million tons were used for domestic purposes. The bulk of this is burned in open firegrates, giving a useful heat efficiency of only 15 to 25 p.ct., and worse still, serious pollution of the atmosphere by the production of coal smoke and noxious vapours, which are destructive alike to property and health.

For industrial purposes (other than used by railways, gas and electricity works, coke ovens, manufactured fuel, steamships, and exports), 72 million tons were used, making, with the 38 millions for domestic purposes, a total of 110 million tons, or 44 p.ct. of the total production. Of this, by our present lavish methods, it is estimated we waste some 40 million tons a year, which, at (say) 15s. per ton, means a loss of no less than 30 million sterling per annum to the country.

Gas and Electrical Efficiencies.

In view of suggested Government subsidies for the development of electricity, it is perhaps as well that I should inform the public how the matter stands between gas and electrical efficiencies. I do not desire to belittle the importance and progress of electricity, or to depreciate the valuable service performed by the electric supply industry, but rather to congratulate the electrical industry upon its progress. The handsome dividends it is able to pay its shareholders indicate prosperity, and no necessity for State aid.

The efficiencies of gas, coal, and electrical apparatus given below are the results of reliable experimental investigations with the most modern appliances:

Gas Appliances.

Gas Cooking Stoves of the Best Type

Hotplate boiling burner efficiency . . . . . 57 p.ct net calorific value
Oven cooking (gas at 8d. per therm) . . . . six 2-lb. loaves can be baked for less than 1d.

Gas Fires of Latest Type.

Radiant heat . . . . . 50–55 p.ct. net calorific value
Low-temperature convected heat . . . . 15–20 „ „ „
Flue heat for ventilation. . . . . Balance

Water Heating.

Geyser efficiency . . . . . 85–90 p.ct. gross calorific value
Circulator—boiler efficiency . . . . . 75–80 „ „ „

Furnace Operations.

Melting of yellow brass—pouring temperature 1000° C. . . . . } 2½ to 3 c.ft. per lb. (according to stand-by losses)
Steel annealing . . . . . 3000 to 4000 c.ft. per ton (according to size of articles)

Coal-Consuming Appliances.

Open Grate Fire.

Radiant efficiency . . . . . 15 to 25 p.ct.

Hot Water Supply from Coal Range Boiler.

Back boiler of range has a general efficiency of . . 11 to 12 p.ct.

Coal Range Oven.

Coal burned in the average commercial range, heat transmitted to oven . . . . . 2½ p.ct.

Total Efficiency.

Considering the coal range as a whole, it is estimated that the average efficiency is only about . . . 7½ p.ct.

Electrical Appliances.

Cookers of Best Type.

Hotplate boiling efficiency . . . . . 30 to 50 p.ct.

(according to whether the kettle is bright or black, and the care taken in switching-off the current before boiling actually occurs, allowing the water to boil as a result of the heat emitted by the elements after the current has been turned off).

Oven.

The best type of electrical oven will be found to use the same number of B.Th.U. as the best type of gas oven.

Water Heating.

Electrical immersion-heaters for boiling water have an efficiency of about . . . . . 90 p.ct.

Electrical Radiators.

If placed in the middle of the room, their heating efficiency is . . . . . 100 p.ct.

No allowance is made, however, for ventilation, which is essential, and with which they should be debited.

With electricity at the low price of 1d. per unit, and gas at 8d. per therm, heating operations, irrespective of the type of apparatus, cost from three to four times as much as corresponding operations performed by the aid of suitable gas appliances.

Carbonizing.

The freedom granted by the Gas Regulation Act, 1920, to introduce a method of charge based on potential heat energy supplied, in place of the volume basis, with reasonable liberty to enable gas undertakings to select those coals from the nearest mining centres, has resulted in renewed interest in the carbonization or distillation of coal for gaseous, solid, and liquid products. It is not my intention to differentiate between the various systems of carbonization or auxiliary processes; but I am of opinion that gas-works—more especially the larger ones—should, as far as possible, instal plant that will enable the undertaking to take full advantage of the prevailing economic market conditions, and so reduce the cost of their chief product. My experience during the war, and later with a three months' stoppage of coal supplies, was that ample plant which will produce either blue water gas or any quality of C.W.G., as auxiliary to the coal-gas plant and for emergency purposes, is invaluable.

I find from trustworthy data the thermal efficiencies obtainable per ton of coal or coke used in good ordinary practice with modern plant (not the results of special tests) by the various systems of carbonizing for the production of straight or mixed coal gas, and for C.W.G. or blue water gas per ton of good dry coke gasified, are as follows:

—	Quality of Gas. B.Th.U. per C.Ft.	Gas. P.Ct.	Coke. P.Ct.	Tar. P.Ct.	Heat Used and Lost in Manufacture. P.Ct.	Thermal Efficiency of Process. P.Ct.	Efficiency of Gas Production. P.Ct.
1. Horizontals. .	550	24·97	48·12	5·61	21·30	78 70	54·0
2. Do., with W.G. added . . .	500	28·17	42·12	4·89	24·82	75·18	53·2
3. Verticals with steaming, with W.H. boiler .	450	29·19	40·60	7·68	22·53	77·47	56·4
4. Blue water gas with W. H. boiler . . .	300	62·50	..	..	37·50	62 50	62 5
5. Carburetted W. G. with W.H. boiler .	500	68·00	..	1·75	30·25	69·75	69·2
6. Low-temperature carbonization.	700	13·61	55·33	10·87	20·19	79·81	40 3
7. Complete gasification . .	340	64·26	..	1 00	34 74	65·26	64 9

From these figures, it will be seen there is not much to choose, in regard to thermal efficiency, between the best horizontal and vertical carbonizing plants; but it is

necessary to bear in mind that a high number of therms per ton of coal used may be uneconomic as compared with a lower production by using cheaper grades of coal and smalls—especially is this the case with those undertakings near the collieries. This, however, must not be confused with thermal efficiency, which it should be the effort of all to increase, whatever the grade of fuel used.

For instance, at the Litchurch Works of the Derby Gas Light and Coke Company, by carbonization of cheaper coals and smalls, the over-all thermal efficiency last year was for a mixed gas 70·86 p.ct., and the average cost for coal, coke, and oil 4·48d., *less* residuals 3·34d., or 1·14d. net per therm, for gas of 503·8 B.Th.U. quality. The oil used was only 0·0423 of a gallon per 1000 c.ft., to enable a larger percentage of C.W.G. to meet sudden increases in the demand. The total gas made was 1362½ million c.ft., of which 20·93 p.ct. was blue or slightly carburetted water gas. Thermal efficiency *per se* is not always a reliable guide. The commercial values of ancillary products and their reflex action require to be taken into account in determining the cost of gas into holders. The collateral advantages of blue or lightly carburetted water gas—such as better control of the coke market, saving in capital charges on plant, lower costs for manufacture in repairs and maintenance, and emergency value, which depends to some extent upon local conditions—all require to be taken into account. The manufactured "mixed" gas often has advantages over the single product; and it is for each to study the controlling circumstances.

Complete gasification has not, so far, fulfilled expectations. The low calorific value of the gas produced renders it unsuitable for general distribution over large areas; and also the financial results compare unfavourably with other methods of carbonizing where bye-products return anything from 50 to 80 p.ct. of the cost of coal used. It is suitable as an auxiliary to the coal-gas plant. My experience indicates that it does not possess the same flexibility as blue or carburetted water gas.

It is impossible to exaggerate the importance of doing everything that is possible towards a better utilization of our coal supplies. Hence low-temperature carbonization is attractive, since it produces both gaseous and smokeless solid fuel useful for domestic and trade purposes, and also oil fuel, for which we are now dependent on imported supplies. It has not, however, so far been established by independent data that low-temperature carbonization has yet been placed upon a stable financial basis; and, as compared with high-temperature carbonizing, the efficiency as a gas-making process is low. Also all low-temperature processes depend mainly upon the commercial value of the solid and liquid products.

The admirable reports by the Fuel Research Board, giving the results of experimental investigations on high and low temperature carbonization under skilled scientific supervision, are of the greatest advantage; and I hope this valuable experimental work will be continued. It needs no words of mine to commend research by technical experts to ascertain the properties and suitability, and, by special treatment, to increase the availability of the potential thermal value of, our coal supplies, and so add to the nation's wealth.*

While on this subject, I desire to record great regret at the loss sustained by the death of Sir George Beilby, who was the greatest authority on the problems of fuel research. We owe much to him for active and valuable work extended over many years.

The reports of the investigations by the Research Sub-Committee of this Institution, in conjunction with the Leeds University, into the thermal and chemical efficiencies of manufacture of different grades of gas by various processes, deserve special praise; and the same applies to the investigations by the Refractory Materials Research Committee towards an improvement in the technique of refractories—placing at the disposal of all interested reliable data as regards thermal conductivity, fusion, expansion, contraction, and superimposed weight tests, all of which are so closely allied to successful carbonization.

* By the kindness of Dr. C. H. Lander, Director of Fuel Research, I am able to give as an appendix the experimental results obtained at the Fuel Research Station setting forth the thermal efficiencies for horizontal and vertical retorts, blue and carburetted water gas plants, and low-temperature carbonization. The difference between the thermal efficiency figures of gas production given by the Fuel Research Board and those given by me is mainly due to one set being the result of tests, and the other for actual working results.

RELATION BETWEEN THE HEATING VALUE OF GAS AND ITS USEFULNESS TO THE CONSUMER.

Closely connected with carbonization is the question of the relative usefulness of gases of different heating value and composition, which is not only important to the gas industry, but is one of more or less active controversy.

The investigations by the United States Bureau of Standards into the relative efficiencies of gases differing as widely as natural gas of 1100 B.Th.U. per c.ft. and various grades of manufactured gas from 725 to 500 B.Th.U., and also the reports by our Institution Gas Research Committee on gases from 500 to 240 B.Th.U., indicate that the relative usefulness of various gases for ordinary purposes is directly proportional to their heating value, and that there is no advantage in thermal efficiency for gas of lower heating value, but rather the reverse for gases of low calorific value with high inert content. Hence, within limits, with equal uniformity of quality and pressure, the volume of gas used will vary in inverse proportion to its potential thermal value.

The available heat units supplied in the form of gas are essentially the useful commodity for which the consumer pays, and a measure of the value received. This being so, it is essential that the method of manufacture shall be such as is calculated to deliver to the user the maximum number of heat units at the lowest possible cost, bearing in mind that the gas supplied is suited to the wants and requirements of the district, and the service given is such as will satisfy various users.

My experience indicates that gas of 500 B.Th.U. per c.ft. possesses advantages over that of a lower quality. The efficiency of utilization is somewhat higher, especially if the time required to perform a given operation is taken into account. There is the simplification of accounts and reduction of clerical work, by doing away with the second place of decimals; and, what is perhaps more important, it enables consumers readily to convert volume into therms. The conversion from thousands of cubic feet to therms (100,000 B.Th.U.), and *vice versa*, is simplified, as the thermal equivalent is 5; thus $\frac{1000}{5} = 200$, which is the number of cubic feet to a therm. For variation in price and calculation of dividends under the sliding-scale, a declared value of 500 B.Th.U. is obviously more convenient, as a penny per 1000 c.ft. is equivalent to 1-5th of a penny per therm, and cubic feet in cents as registered by consumers' meters divided by 2 equals therms.

From the National Gas Council return of Orders granted under section 1 of the Gas Regulation Act, 1920, up to Dec. 31, 1924, I observe the declared calorific standards are as follows:

Number of Gas Undertakings.		Calorific Value. B Th.U. per C.Ft.
4	..	270 to 375
66	..	400 to 440
135	..	450
55	..	460 to 470
60	..	475
45 (277)	..	480 to 490
172	..	500
28	..	510 to 600
Total . . 565	Average . .	472

Of the above, 76 have increased their declared value and 8 decreased it; and it will be seen that 277, or almost one-half of the total of 565, supply gas of from 474 to 500 B.Th.U. The tendency is upwards towards the 500 B.Th.U. standard, which seems to me to be in the right direction. It is of interest that the average declared value of the whole 565 undertakings is 472 B.Th.U.

I think there is much to be said for a uniform calorific standard of (say) 500 B.Th.U. for the whole country. This would simplify the adjustment of gas apparatus, and tend to reduce manufacturers' costs. Those who advocate supplying gas of low calorific value appear to ignore distribution costs, which are far from being a negligible item.

POWER FOR INDUSTRIAL AND OTHER PURPOSES.

It is generally acknowledged that a modern gas engine is one of the most efficient prime movers available to-day; yet there has been a falling-off in their use of recent years, as a result of keen competition by electric motors—cur-

rent being sold at extremely low rates for power purposes. A formidable competitor is also the crude oil engine. There has been a marked decrease in the use of isolated steam power, except for large users or in special cases where steam is required for other purposes. The smaller steam engine, as regards convenience, availability, and costs, compares very unfavourably with gas, oil, or electricity.

Electricity is an efficient and convenient means of transmitting power. In some instances electric motors are no doubt more convenient and economical than any prime mover; but where the load is reasonably continuous, a gas or oil engine may effect a substantial reduction in running costs.

For crude oil engines, with a low price of £6 per ton for crude oil delivered by road tank-cars, the fuel cost alone is less than for town gas, unless supplied at a specially low rate; but this is only one item. The initial cost of an oil engine is greater than for a gas engine. There is the storage of oil and uncertainty as to its price, increased wear and tear, also higher costs for maintenance and attendance, all of which require to be taken into account when estimating over-all running costs.

Town gas possesses several advantages over producer gas or oil for power purposes. It is always available, there is no cost of storage or getting-in supplies, it is more reliable, needs less attention, and smaller initial outlay is required.

For power purposes it constitutes a desirable proposition, both for suppliers and users. The load factor is a good one; and it will pay gas undertakings to charge lower prices to encourage its extended use for power, to compete with oil and electricity. Severe competition will compel manufacturers to look more closely into production costs; and there are many industries where a modern type of gas engine will effect an appreciable saving over electric motors.

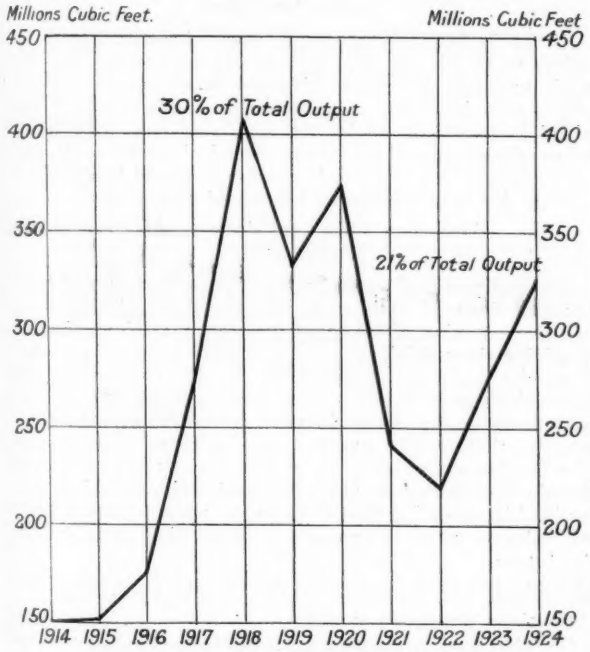


Fig. 2.—Derby Gas Light and Coke Company.

Chart showing gas used for Motor Power and Industrial Purposes, 1914-24.

It is now over twenty years since the Derby Gas Company supplied and fixed gas engines on advantageous hire-purchase terms or sale outright; and the Board recently decided to let gas engines out on simple hire. The reduction in price charged for gas used in Derby for motive power and industrial purposes varies from 15 to 21 p.ct. (according to quantities used) below the initial price of gas. Fig. 2 indicates the large increase in the sale of gas for power and industrial purposes during the last ten years.

The decrease from the maximum of 407 million c.ft. in 1918 to 220 million c.ft. in 1922 was due to post-war effects. Output is now on the increase. Last year (1924) the quantity reached 326 million c.ft., so, notwithstanding continued trade depression, the increase during the last decade is 183 million c.ft. per annum, or 128 p.ct. In 1918 it was 30 p.ct., and last year 21 p.ct., of the total output. This indicates the importance of catering for power and industrial users. Both mean a regular demand all the year round.

In our case, the cost of gas for an engine of (say) 50 H.P. full load is only about one halfpenny per B.H.P. hour. I think you will agree this is cheap power, and that there is no necessity for the Government to subsidize power or other companies to enable manufacturers to obtain cheap energy, as the gas industry is supplying gas at prices which enable manufacturers to obtain power cheaply.

The reliability of modern gas engines, as compared with steam or electric, is at least equal, if not superior to, that of either.

The larger gas undertakings will be well advised to establish a power department under the charge of a skilled mechanic, competent to advise manufacturers, test, and carry out repairs and adjustments to gas engines. It cannot be expected that small gas undertakings can afford the expense of running a separate well-organized power department. I suggest that the larger works should co-operate with the smaller ones, so that the benefit and economy of using modern gas engines running on town gas may be extended over the country to the mutual advantage of producers and users.

I think it only fair to acknowledge that the great increase in the use of gas for numerous industrial purposes is due largely to the skill and enterprise of those who design and make gas apparatus, and to the praiseworthy propaganda work of the British Commercial Gas Association in making known the economy and advantages attending the use of gaseous fuel—work which is actively supported by gas undertakings. I am mindful of the excellent work done by the Society of British Gas Industries, and think this Institution and that Society might become more closely associated with advantage; an interchange of views must always be beneficial to both sides.

Smokeless Gas Coke.

The mild winter in Northern Europe and consequent diminution in demand for coke have led to accumulation of stocks throughout the country. Undertakings which in normal circumstances rely to a large extent on the export market for coke are naturally the hardest hit; but the seriousness of the coke position throughout the industry calls for united action with a view to promoting an increase in its use for industrial, as well as for domestic, purposes.

It is not sufficiently appreciated by industrialists, and especially by those who are genuinely concerned and anxious to mitigate the smoke nuisance, that, in addition to its valuable smokeless characteristic, gas coke, either by itself or in admixture with small coal or slack, can and does effect economy in steam raising. Whereas coal slack in normal every-day boiler practice will evaporate on the average about 6 to 7 lbs. of water per pound of slack, coke of good average quality will evaporate upwards of 9 lbs., and will in addition afford complete relief from the consequences of smoke emission.

Proof of the growing appreciation of the inherent advantages of gas coke as a fuel is evidenced by its extended use on the "Sandwich" system at electricity supply and tramway power stations. A contract recently concluded between the London County Council and the South Metropolitan Gas Company (who invariably lead the way) provides for supplies of coke to the Greenwich power station at a rate approximating 50 p.ct. of the total weekly fuel consumption of the station—viz., 3000 tons per week.

The practical consummation of the ideal of closer co-operation, in the national interests, with our electrical friends, is here clearly indicated; and a wider adoption of the "Sandwich" system, which has rendered the use of coke at power stations not only practicable but economical, as compared with coal alone, would tend not only to foster such co-operation in the interest of all concerned, but to remove, at least to some degree, the stigma that unavoidably attaches to the complete destruction of coal when used as fuel in its raw state for the generation of electrical power.

While the use of pulverized coal as fuel at power stations tends towards improved efficiency of combustion, it does not justify in the least the use of raw coal; and while the pulverized coal system may be regarded as an important development in power station equipment, the recent adop-

tion of the "Sandwich" system of coke firing at an important new power station (Barton) brings the latter system right abreast of modern boiler-house practice.

The promotion of domestic uses for coke will, however, appeal to most gas undertakings; and if constant and abundant hot water is admitted to be indispensable in modern domestic and personal hygiene, then a coke-fired boiler must be regarded as a necessary adjunct to the modern household. Herein lies an immense field for expansion.

I should like to commend the propaganda work of the London Coke Committee and their very able fuel expert, Mr. E. W. L. Nicol, Assoc.Inst.C.E., M.I.Mar.E. I think that provincial gas undertakings might with advantage combine to do something in the same direction. All gas undertakings should, by advertising in the local Press, and by circulars, draw attention to the merits of this solid smokeless fuel, and see that facilities are afforded for delivery in small quantities, by means of bags, &c. I observe from "Field's Analysis" for 1923 that the income from coke and breeze of the three Metropolitan Gas Companies was £2,738,108—equal to 2·445d. per therm, or 12·61d. per 1000 c.ft. on gas sold, which indicates the importance of this source of revenue, and the necessity for doing everything possible to promote and popularize the use of coke.

Proposed Government Assistance to the Electric Supply Industry.

I do not, as a rule, refer to a competitive industry; but the proposals put forward that Government assistance should be given to bring about the reorganization and expansion of the electricity supply industry by an issue of Electricity Bonds to an ultimate total value of £50,000,000, guaranteed by the Government, is so manifestly unfair, not only to the gas industry, but to many other industries, that I desire to enter an emphatic protest against any such one-sided scheme to which there are many objections, both on principle and as regards its application.

There is ample room for both gas and electricity in their own spheres; and before any legislation is introduced, the country ought to be made aware of the whole facts, and an answer given to the very important question: To what extent can power and heat and light be cheapened by the conversion as now practised of the potential energy of coal into electric current, or by the more logical way of distillation for separation into gaseous, solid, and liquid products?

It is an admitted fact that the highest thermal efficiency in the utilization of coal is achieved by the gas industry. The efficiencies of gas and electricity in production, distribution, and utilization are as follows:

—	Number of Heat Units Delivered to Consumer per 100 Heat Units in Coal Used — Thermal Efficiency of Manufacture and Distribution.	Number of Heat Units Converted into Useful Work by Consumer per 100 Heat Units in Coal Used.			
		For Heating Rooms.	For Heating and Boiling Water.	For Cooking by Oven.	For Power.
Gas: Average present practice	47·5	29	35	6·2	11·2
Electricity: Average present practice	9 5	9·5	4 8	2·1	8·65

From these figures, it is evident that the maintenance and development of the gas industry are essential in the interest of fuel conservation, apart from other questions.

The proposal for giving an artificial stimulus to the electricity supply industry by means of Government financial assistance should, I think, be considered as to the probable effect of this unprecedented departure:

(1) On national grounds.
(2) From the point of view of:
  (*a*) The electricity supply industry.
  (*b*) Municipal enterprise.
  (*c*) The gas industry.

(1).—National Grounds.

Artificial stimulus to any industry by means of State aid is without precedent, and is essentially contrary to the financial or fiscal policy of this country. State aid to any particular industry constitutes a form of domestic internal protection at the expense of other industries. Coal is our great national asset; and I have already shown that the highest thermal efficiency in the utilization of coal is obtained by high-temperature carbonization.

Cheap electricity is not a panacea for all industrial ills. I find that in most industries the percentage for power costs, as compared with total production costs for materials, labour, rates, and overhead charges, varies from 1 to under 5 p.ct. only—*e.g.*, engineering 2·95, motor cars 2·40, printing 1·90, and paint 1·95 p.ct. For malleable iron castings it is 3 p.ct. only of the total cost per ton. Hence, it will be seen that the plausible cry that industry will revive if only manufacturers can obtain motive power at abnormally low rates is misleading, and will only delude those who put their trust in doctrinaire promises.

It should not be overlooked that the gas industry itself employs five men for every one engaged in the electricity supply industry on the same amount of work done.

Government money spent on the development of electricity may be wasted on uneconomic and unremunerative schemes. The electrical industry itself is sufficiently prosperous to pay for any schemes which would result in a fair remuneration on the capital expended. The pre-war and post-war dividends paid by the Metropolitan and Provincial electric supply companies amply prove this.

Further, it is quite probable that within the next few years a gas turbine will be perfected which may render obsolete the most efficient methods for the generation of electricity in use to-day, and may well make long-distance distribution of electrical current an unnecessary and wasteful practice.

(2).—From the Point of View of the Electricity Supply Industry.

Great doubt is felt by a large body of electricians themselves as to whether any scheme of Government financial assistance can be to the ultimate benefit of the electricity supply industry. The inevitable result of any State-aided uniform scheme for the supply of electricity would be to stereotype and crystallize electrical practice. Future progress would be impeded, cheapness would be retarded, and the industry and the nation would alike suffer.

(3).—From the Point of View of Municipal Enterprise.

The setting-up of super-power stations by means of Government financial assistance must entail the closing-down of a large number of municipal generating stations, thereby depriving the municipality of the control of its own works. Financial assistance granted by the Government to the electricity supply industry must tend to jeopardize municipal enterprise in probably its most successful department—namely, that of gas supply. In this respect, it is noteworthy that about 40 p.ct. of the gas supplied in Great Britain is provided by municipal undertakings, which are justified in expecting that Parliament, which created them, will take no steps to hamper or harass their activities in the future.

(4).—From the Point of View of the Gas Industry.

On these grounds I submit:

(1) That no case has been made out for any subsidy being granted to the electricity supply industry.
(2) That if the Government is determined to adopt a policy of national subsidies, then all rival and competitive trades and industries should receive like subsidies on the same terms and conditions.
(3) That such subsidies should take the form of loans repayable with interest over a period of years by the industry or undertaking assisted, in a similar manner to loans (sanctioned by the Government) to municipal trading departments.

Conclusions.

In the foregoing remarks I have very imperfectly endeavoured to draw attention to some of the more salient matters, confining myself chiefly to those which seem to me to have the most bearing upon the future of our industry.

Labour-aiding appliances do not, as fallible prophets visualized years ago, result in reduction of employment, but in increased output. The descendants of these same prophets think they hear, in the hum of the big electro-turbo generators, the knell of our industry. They are mistaken. Like many other businesses, the gas industry really began to expand when it had to hustle for business. The possibilities in the use of gas are greater than ever; and

I look with confidence to a large extension in its applications both for industrial and domestic purposes.

Before I conclude, I desire to thank those who responded to my recent appeal for increased support to our Benevolent Fund, which really merits more support than it receives, and should rest on a wider basis of annual subscribers. There is a well-known saying, "Charity begins at home." It cannot better begin than in assisting to help those of our calling and their dependants who, through circumstances beyond their control, are no longer able to provide for themselves. I venture to put this before you, not as a duty but a privilege of those who possess the means to help those less fortunate.

APPENDIX.

Thermal Values of Gas Coals and Coke, and Thermal Efficiencies of Horizontal and Vertical Retorts, Blue Water Gas, Carburetted Water Gas, and Low-Temperature Carbonization, compiled by the Staff of the Fuel Research Station, by permission of the Director of Fuel Research.

Thermal Value of Gas Coals and Cokes.

The thermal value of coals varies with the nature of the coal. In gas coals from the same district the variation is normally small when reckoned on a dry ash-free basis.

—	Moisture.	Ash.	Gross Calorific Value.	
			B.Th.U. per Lb.	Dry Ash-Free Coal or Coke.
Coal—				
Durham	1·5	7·0	14,040	15,340
Yorkshire	1·5	7·0	14,030	15,330
Nottinghamshire, Derbyshire	Survey of this coalfield has not yet commenced, and figures are not available.			
Coke—				
Horizontal (1)	1·5	10·2	12,570	14,230
Vertical (2)	0·6	10·7	12,500	14,100
Low temperature (3) (Volatiles 8 p.c.)	2·5	8·0	13,200	14,750

(1) Durham coal.
(2) Yorkshire coal.
(3) Since the ash in low-temperature coke becomes very apparent on combustion, this commodity is not likely to appeal to the average consumer unless care is taken to reduce the ash content of the raw material by washing, if necessary. The figure given is based on an ash content in the coal of 6 p.c.

Horizontal Retort Practice.

DURHAM COAL.

	Therms.
Gas	71·8
Coke (total)	207·5
Tar	18·3
	297·6

Taking coal as 14,040 B.Th.U. per lb., or 314·5 therms per ton, the thermal efficiency is 94·5 p.ct.

The carbonizing efficiency, taking 32·0 therms of coke consumed on the retorts, is 84·4 p.ct.

Vertical Retort Practice.

In order to obtain the necessary 500 B.Th.U. standard specified, steaming to the extent of about 8 p.ct. only would be possible with (say) Yorkshire coal:

	Therms.
Coal	314·3 (ash 7·0 p.ct., moisture 1·5 p.ct.)
Coke (total)	186·5
Gas	90·0 (500 B.Th.U. per c.ft.)
Tar	20·0
	296·5, or 94·3 p.ct.

These are Fuel Research Station results; and it is not possible to allocate directly the amount of heat required for auxiliary operations. These can, however, be deduced from the Gas Institution results obtained at Uddingston:

Fuel to setting	30·2 therms per ton of coal
Fuel to raise 8 p.ct. of steam	2·9 " " "

In a modern plant equipped with a waste-heat boiler, sufficient steam could be raised to supply the retorts, the tar, &c., pumps, and probably the gas exhausters.

The net efficiency of the system would therefore be 84·7 p.ct.

Without a waste-heat boiler this figure would be reduced to about 81·5 p.ct.

Blue Water Gas.

The following figures are taken from Fuel Research Station experiments, with calculated allowances for fuel consumed in the process. Figures taken from the Gas Institution work are also shown for comparison, since these were obtained during the actual commercial operation of a plant.

—	Fuel Research Station.	Gas Institution.
	P.Ct.	P.Ct.
(1)—Efficiency of generator	57·81	50·2
Lost in steam raising	3·15	..
Power to blower—		
(1) Electric fan, 14 p.ct. efficiency	2·15	..
(2) Steam turbo blower	6·25	..
Net efficiency of plant—		
(1)	54·9*	
(2)	52 8*	46·3
(2)—If the plant be equipped with a waste-heat boiler, the following efficiencies arise—		
Efficiency of generator	62 4	53·7

* This net efficiency does not make allowance for extra services such as transport of coke, &c.

Carburetted Water Gas.

The following figures are taken from the report by the Gas Investigation Committee. The Fuel Research Station have no data on this process.

Efficiency of water gas generator (excluding steam)	53·7 p.ct.
Efficiency of carburetted water gas production	68·0 "

The efficiency of the "cracking" process was, in these experiments, about 76 p.ct. This agrees with figures supplied to us from time to time by other investigators.

The steam generated in the waste-heat boilers is sufficient to supply all requirements.

Low-Temperature Carbonization.

FUEL RESEARCH STATION.

Vertical Cast-Iron Retorts (630° C.).

	Therms.
Coal, 1 ton	280·0 (moisture 6·6 p.ct., ash 8·9 p.ct.)
Coke, 13·7 cwt.	192·2 (ash 11·0 p.ct.)
Gas, 6970 c.ft.	45·2 (648 B.Th.U.)
Tar, 14·6 gallons	24·9 (sp. gr. 1·07)
	262·3, or 93·7 p.ct.

(1) Fuel gas to setting, 29·2 therms (2500 c.ft. of water gas per hour, 0·25 tons per 4 retorts per hour).
(2) Steam to retorts (up to 10 p.ct.) from waste heat.
(3) Crushing of coal, 1·0 therms.

Net efficiency, allowing for (1) only = 83·2 p.ct.
for (1) and (3) = 82·9 "

BARNSLEY.

	Therms.
Coal, 20 cwt.	305·5 (moisture 5·2 p.ct., ash 4·5 p.ct.)
Coke, 13·92 cwt.	214·0
Gas, 5620 c.ft.	39·6 (scrubbed)
Tar, 18·62 gallons	32·7
Spirit, 1·78 "	3·1
	289·4, or 94·8 p.ct.

Fuel to settings was excessive during the Fuel Research Station test, and should be reducible from 41·8 to about 35 therms per ton. All steam necessary could be supplied from waste heat.

Net efficiency, 83·3 p.ct.

SOCIAL EVENTS.

THE PRESIDENT'S RECEPTION.

To the President and Mrs. Ferguson Bell some 600 guests are indebted for open-handed hospitality and entertainment at the reception and dance they offered at the Connaught Rooms, Great Queen Street, on the Tuesday evening. Mr. and Mrs. Ferguson Bell, with their daughters, stood for an hour receiving their many guests; and they had a smile and a word of welcome for all. Mrs. Bell carried a beautiful bouquet of yellow roses, presented to her by the Midland Association of Gas Engineers and Managers, and the Misses Bell had been the recipients of sheaves of carnations from Sir Arthur Duckham.

To mention the names of the many distinguished guests would overtax the space allowed in a technical journal for the recording of a social event; but it is our custom to select those who were present as representing the industry's organizations. They were: Of the Institution of Gas Engineers: Mr. C. F. Botley (then Senior Vice-President); Mr. John Wilkinson, O.B.E. (Junior Vice-President); Mr. W. E. Price (Hon. Secretary); and Mr. Walter T. Dunn (Secretary). Of the National Gas Council: Mr. Ernest J. Fottrell (Joint Manager). Of the British Commercial Gas Association: Mr. F. W. Goodenough (Executive Chairman) and Mr. W. M. Mason (Manager). Of the Society of British Gas Industries: Mr. B. B. Waller (Chairman of Council); Sir Alfred Mond, the President, was unavoidably absent, but communicated his deep regrets and good wishes to Mr. Bell. Mr. W. J. A. Butterfield represented the Gas Referees, and Prof. John W. Cobb, C.B.E., the University of Leeds. Mr. Hermann L. Shepherd, Lt.-Col. W. R. Glover, C.M.G., D.S.O., and Mr. James Bridge represented, as their W.M.'s, the Evening Star, the Murdoch, and the Northern Star Lodges respectively. There were present many Past-Presidents of the Institution, including Mr. Samuel Tagg, J.P., Mr. Bell's immediate predecessor; and the District Associations were strongly represented by their officers. "H. E. J." was sadly missed, but all found pleasure in greeting his son, Mr. Frank H. Jones, Vice-President of the South Metropolitan Gas Company. Mr. Reginald Clarry, M.P., was there; but the President of the Institution of Electrical Engineers was detained by the annual meeting of that body in the Midlands, and wrote expressing regret and the greetings of the sister Institution.

Mr. Ronald Glover, M.C., was assiduous in his duties as Master of Ceremonies, and the thanks of all are due to him, as to the following gentlemen who acted as Stewards: Messrs. E. J. Fottrell, H. H. Gracie (Edinburgh), H. D. Madden (Cardiff), W. E. Caton (Oxford), F. H. Robinson (Harrogate), P. G. G. Moon (Bournemouth), F. A. West (Newark), and J. D. Smith, J.P. (as the representative of Ireland).

In spite of the following of last year's excellent precedent of holding the reception at the Connaught Rooms instead of Prince's, the large company overflowed the great banqueting hall, and Mr. Ferguson Bell thoughtfully arranged to have the smaller reception room thrown open as a buffet and sitting-out room. Dancing began at 9 o'clock, and continued, with a short interval, till midnight; the band acquitting themselves nobly in rendering popular dance music with vigour unabating in spite of the warmth of the evening. Nearly everybody danced, and the whole proceedings went with a swing which culminated in an eightsome reel rendered by three sets with characteristic energy, and which reminded many of us Sassenachs that dancing in its truest sense is an art not totally obliterated.

Congratulations to Mr. and Mrs. Ferguson Bell upon the excellence of their generosity and arrangements!

THE LUNCHEON.

The President of the Board of Trade as Chief Guest.

At the close of Wednesday morning's session, a large party repaired to the magnificent premises in Pall Mall of the Royal Automobile Club, in response to an invitation by the President, Vice-Presidents, and Council of the Institution, to meet at luncheon the Right Hon. Sir Philip Cunliffe-Lister, K.B.E., M.C., M.P., the President of the Board of Trade. Many who are well known to all in the industry, and beyond it, were there; but of them it is possible here to mention only a few. The President (Mr. J. Ferguson Bell) occupied the chair; and on his right were Sir P. Cunliffe-Lister, Dr. Charles Carpenter, C.B.E., Mr. R. G. Clarry, M.P., Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., Mr. Henry Woodall, Mr. Thomas Goulden, Mr. Thomas Hardie, and Mr. H. C. Honey. To the President's left sat the Right Hon. J. H. Thomas, P.C., M.P., Mr. W. Woolley, Mr. D. Milne Watson, and Major-General Sir R. Luce, M.P. The vice-chairs were occupied by the Vice-Presidents of the Institution (Mr. C. F. Botley and Mr. J. Wilkinson). Among the visitors, also, were Presidents, &c., of kindred associations. After the Loyal Toasts had been honoured at the call of the Chair,

FOUR SQUARE IN DEFENCE OF THE EMPIRE.

The Right Hon. J. H. THOMAS, who had to leave early to fulfil another engagement, said their Chairman and the President of the Board of Trade had consented to his toast taking precedence. As a matter of fact, it really ought to take precedence, because it was the toast of "Success, Prosperity, and Long Life to the Institution of Gas Engineers." Although "long life" was not included in the toast as printed, he had deliberately added it, as a sentiment to which they would drink with enthusiasm. He was really in some difficulty to know quite the reason that would warrant them in accepting him as a fitting person to propose the toast; but after all, it might not be hard to justify it. They were gas producers; while the politicians were gas distributors. [Laughter.] He was also one of the Members of Parliament for Derby; and whatever might be said about the gas undertakings in other parts of the country, they must believe him when he told them that Derby of necessity stood supreme. This was evidence of their wisdom in appointing as their President a Derby man. Now, he had been asked to propose "Prosperity to the Institution"—an Institution that was not only represented there by distinguished men in the profession, but that included in its membership people from overseas—in fact, from all parts of the world. He would say to the Overseas Dominions: "We welcome you among us as grown-up sons and brothers." Then he would say to their foreign colleagues who were represented: "We welcome you for what you can contribute to the world in science and knowledge." Because, after all, the real object of that Institution—the one thing above all others that justified its claim to support—was to encourage the acquisition by young men of fresh knowledge. This was why he thought it was the duty of all to give their blessings to the Institution. Referring to politics in this country, he would just like to say one thing to their Colonial and foreign guests—the failure to keep in mind which sometimes led to confusion of thought and difficulties that would be avoided if it were remembered. It was this: "Whatever may be the political differences—and they are many—whatever may be the political fortunes of parties, whatever may be the interests of class or creed, in this country, the past history of our country proves, and everything that we see to-day demonstrates, that there is no varying of the policy that, however much we may quarrel among ourselves, when the real fundamental issue of the Empire and its welfare is involved, they will always find us standing four square in defence of that Empire." ["Hear, hear."] Because the members of the Institution had an opportunity of meeting together, of exchanging views, of understanding one another better, and of pooling their knowledge (which was not knowledge of benefit to them alone, but must always be of benefit to the community), he was delighted to be present among them and propose the toast of "Success, Prosperity, and Long Life to the Institution"—with special emphasis on the words "long life."

OUT FOR EFFICIENCY.

The CHAIRMAN, responding, expressed high appreciation of all the kind things that had been said about the Institution and the gas industry by Mr. Thomas. Public utility services were not always appreciated as they deserved to be. The efficiency of their industry was what they were out for. They were out to serve the public by giving them an ample supply of gaseous energy at the lowest possible price. He ventured to think such social functions as the one they were then enjoying were helpful to all parties, because misunderstandings often arose through misapprehension of facts; and it was well that people should realize there were two sides to most questions. They were glad to welcome Sir Cunliffe-Lister, not only as President of the Board of Trade, but for his own personal sake. They were also pleased to have with them several other distinguished visitors. The Institution dated back to 1864, so that it was a fairly old one. An education scheme had been introduced, so that those who were to come after them might be suitably technically equipped to perform the duties that they would be called upon to fulfil. They as an Institution were anxious to maintain the gas industry; and, as he said, they were out to make it, if possible, still more efficient. The gas industry was full of vitality instead of being, as some people thought, in a state of decay; and he ventured to declare that the next few years would witness still greater development. He had referred in his address to the great development of gas in the United States of America; and the same could be said of the industry on the Continent of Europe and in other parts of the world. The gas industry of this country, with its allied trades, had a capital of something like £200,000,000,

and provided practically permanent employment to about 125,000 men—which in these days of unemployment was something to be proud of.

SELF-HELP AS A REMEDY.

Mr. D. MILNE WATSON said it was with great pleasure that he rose to give the toast "Trade and Industry," coupling with it the name of the President of the Board of Trade, Sir P. Cunliffe-Lister. They were very pleased indeed to have him among them. At the present moment the trade of the country was going through a very bad time, and unemployment was rife. It was three times what it was before the war, and everybody was looking for a remedy. Personally, he did not believe that any miracle was going to take place to help them out of their difficulty; to his mind the remedy for the present troubles was self-help ["Hear, hear"], coupled with lower taxation. If employers and employed were prepared to make sacrifices, he did not believe the country would be long in getting trade started again on a pre-war basis. The trouble was that everyone was looking for help from outside. It rather reminded one of the family in financial stress, who sat round a table to discuss matters. The son said: "My allowance must remain the same." The daughter said: "I must have my motor-car and horses as usual." And the father ended up by saying: "I must have cigars and wine as usual." There was nothing to be said about the mother; she was always self-sacrificing. What he had portrayed was very much the position of industry at the moment. No one—either one side or the other—wanted to give up anything. But he felt perfectly certain that, until this idea was got rid of, they were never going to get straight again in this country. No speech from him would be considered complete without some reference to Scotland; and he would like to ask them: "Do you think that little tribe north of the Tweed would have come into the position of being the rulers of the world if they had not been prepared in the early days to make great sacrifices for education—if they had not been prepared to work in the summer time at the harvest, in order, during the winter time, to be able to go to the school and college? Do you think they would be occupying the position they now do all over the world if they had waited for the Carnegie Trust for education?" In a little fable by Æsop, a farmer said to his sons: "I am going to leave you a field, and in that field is hidden great treasure. If you go there, you will find that treasure." The old man in due course died, and his sons got pickaxe and spade and started to dig over the whole field, expecting to find gold and silver treasure buried in the vineyard. They never found it; but after working and cultivating, they had the best vineyard in the country, and had their reward in bountiful crops. That was the moral for this country. They must not go looking for hidden treasure. It was by work alone that this country, and its industry and trade, would get right. They were thinking too little about self-help, and too much about what Government assistance they could get.

THE CASE OF ELECTRICITY.

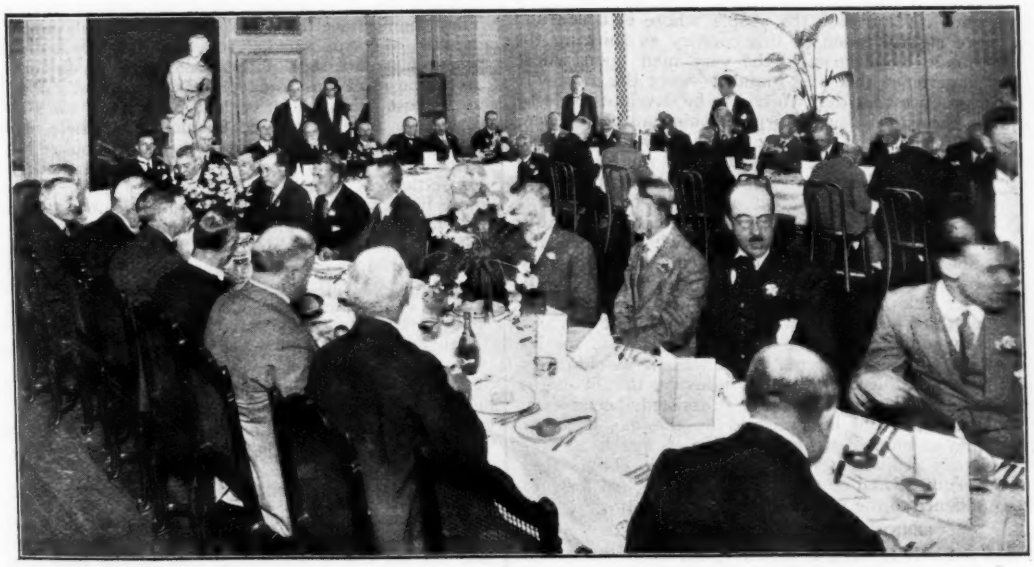
Take this illustration of electricity. It was said by many learned professors and many politicians that too little electricity was used in this country, and that it was too dear; and they compared the amount of electricity utilized in this country with other countries, and found that in Switzerland the figure was 700 units per head, Canada 612 units, the United States 472 units, France 147 units, Germany 141 units, and Great Britain about 139 units. It would be noticed that a certain group of countries—Switzerland, Canada, Norway, the United States, and Sweden—used a large amount of electricity, and that the three countries he had last quoted—France, Germany, and Great Britain—consumed about the same quantity. What was the reason for this? That the first group had water power, and could use this to generate electricity; whereas in this country, Germany, and France there was coal, and these coal countries were developing on a line of their own. They were not only turning a certain amount of coal into electricity, but also turning it into gas, of which they used much more, because it was the natural way in which to utilize the resources of the country. The other point was that it cost too much in this country. Well, electricity in many districts of this country cost half what it did in Switzerland. Electricity on the North-East Coast was equal in price to Chicago—a startling figure; yet in spite of this they were told that, if they obtained Government assistance and organization for electricity they were going to have less unemployment and smokeless towns. As for less unemployment, with equal rates for electricity, in Chicago trade was booming, while on the North-East Coast it was more depressed than anywhere else. How could they think that electricity had anything to do with it at all? If electricity had been given away, it would not have preserved many recent contracts for this country. It was hunting a "will o' the wisp" to say that electricity was going to solve the unemployment problem of this country. They had been told at Barking that electricity was going to purify the air. Gas had already purified the air—that was his answer. Going along King's Road, Chelsea, he happened to pass the Fulham Gas-Works, and there the air was clear and bright. Near by was the Lots Road Power Station, with the chimneys belching forth smoke. So much for the purification of the air.

LOW-TEMPERATURE CARBONIZATION.

Next he came to the question of low-temperature carbonization. It had been stated in the papers that if only the Government would give £10,000,000 low-temperature carbonization would save the country. Did they seriously think that the manufacturers and the owners of private capital in this country were such fools that if they thought £10,000,000 could have made a commercial success of it, they would not have invested it in low-temperature carbonization? Yet, apparently, there were a large number of people who believed that £10,000,000 of Government money could make a desert blossom, whereas £10,000,000 of ordinary capital could do nothing.

BRITISH TAR FOR BRITISH ROADS.

Then there was another matter of which he had read in the papers that morning. When they had a man like Sir Henry Maybury, occupying a high position in the Ministry of Transport, referring to the use of bitumen for roads, and then going on gratuitously to say: "As for tar, it sticks to everything except the road," was this a helpful thing to British industry? ["No."] It was a scandalous thing. One of the highest officials in a Government Department deliberately crabbing one of the biggest products of this country, and throwing his weight on to the side of an imported substance which cost twice as much! If they wanted to help the trade of this country, why did not they say: "Use British tar for British roads"—except for the 4 p.ct. of roads which lay along trout streams, if they liked? Even in London, trying to make them use bitumen instead of tar! It was a scandal. Could they imagine any body of Germans or Frenchmen sitting round a



LEFT TO RIGHT at Top Table: Mr. Reginald Clarry, M.P., Dr. Chas. Carpenter, C.B.E., Sir Philip Cunliffe-Lister, Mr. Ferguson Ball, Mr. J. H. Thomas, M.P., Mr. Wm. Woolley, Mr. Milne Watson, D.L., and Major-Gen. Sir R. H. Luce, M.P.

table, who would scheme how to get a foreign substance used instead of their home commodity? He would not have referred to the matter in such a way had he not felt that this adoration of what came from abroad did more harm to British trade than anything else at the present moment. [Applause.] "I believe," concluded Mr. Milne Watson, "that if we would only put our backs into it—each one and everyone—employer and employed—this country would win through. I cannot believe anything else. I couple with the toast the name of Sir Cunliffe-Lister; and I hope he will remember that gas is especially entrusted to his care."

THE PRESIDENT OF THE BOARD OF TRADE REPLIES.

Sir PHILIP CUNLIFFE-LISTER, in response, said he was very glad they had given him an opportunity of taking some small part in one meeting connected with this most interesting and valuable conference. The members of the Institution were the High Priests of a great and successful industry—an industry which was the architect of its own success. This success was founded upon skilful management, upon constant scientific research, and upon not only the direct production of their main commodity, but on valuable, and increasingly valuable, bye-products. The industry was a model of good relations between employers and employed; and it was also a model in the service which it rendered to the public. He wished really that he had as little difficulty in defending many things as he had on the whole in defending Gas Orders. As he had said, the industry was giving good service to the public; and where the industry prospered, the public, or consumers, came in and shared both in the quality of the article which they received, and in the price at which they received it. This was really a public service; it was really being a public utility undertaking. Lastly, but by no means least, the gas industry was not lacking in what he believed to-day was a matter of the most vital importance, if Britain and British trade and industry were to get the fullest value out of their assets—namely, development. In the face of the increasing output of gas—doubling, trebling, quadrupling decade after decade—anybody would be a fool who said the age of gas had passed. There could be no possible question that there was not only a great need for this industry, but a great future before it. He could promise them that at the Board of Trade they would not be unmindful of the gas industry. But this was really quite an unnecessary undertaking to give to those present, because there were millions of consumers all over the country who were the real safeguards of the interests of the industry which had served them so well in the past. It appeared to him that a great deal of the suspicion that existed to-day—he was not going to make any pronouncement upon Government schemes, for he was not in a position to do that—rested upon a profound misunderstanding of elementary facts. There were many people always prepared to talk a huge amount of nonsense about subjects with which they were largely unacquainted. He had often seen a case damned by being put too high; and from some experience of the gas industry at the offices of the Board of Trade, and some small direct experience of helping to run electricity undertakings in different parts of the world, he said that, whatever politicians of one complexion or another might urge, facts had undoubtedly established that gas and electricity were not necessarily enemies, but that both, worked at the highest efficiency, were vital to any country. He thought those present, who certainly knew more of the gas side than he himself did, would probably bear him out in this: That if they took those parts of the United States where electricity had been most ably developed, they would find gas most ably developed side by side with it; and that the people whose evidence and experience were rightly taken in this country as showing the great strides made by electricity—the very men upon whose evidence and experience this was founded—were the men who had proved in practice that the two had to be developed side by side. So far in the past when Government aid had been given, gas and electricity had been treated on absolutely identical and equal terms; and he was quite sure that any representations which the gas industry might have to make with regard to any proposals that might be put forward, would be considered at their full value, both in Government circles and by the House of Commons. This was only fair play, which they had the fullest right, not only to ask for, but to demand. But they must not spoil their rightful claim by putting it too high. Do not let them, for example, say, if in some industry—whether electricity or anything else—there was some development which was economically sound and in the interests not only of the industry but of the country at large, which was in its character and its essence applicable only to that industry, that it ought not to be put in hand, and if necessary assisted, because an identical scheme could not be prepared by the gas or other industry. If they attempted to make a case of this kind they would be seriously prejudicing the very valuable claims they had on the Government and on the country. He looked forward with great confidence to the future of the gas industry.

SERIOUS TRADE POSITION.

The toast was not only to the gas industry, but to the trade and commerce of the country; and he wished he could take at this moment an equally hopeful view of all the other industries as he did of gas. If they could show the same advance and the same prospects, if they had only to face the same competition, he should be greatly more hopeful of their future than he was that day. The trade position was unquestionably serious; and it was no use blinking facts. It was serious because they were doing too little business—far too little business—for the population they had to support. There was something about the matter, too, that was not seen in any official return, but which every trader was aware of—and that was the diminishing margin upon which a great deal of this business was being done. In many cases it was at an actual loss; and this was serious. There was another thing that was serious—namely, the disparity between this country's imports and exports. The need was to develop new markets; and this meant that they must have more money to invest. The greater the deficit to be made up in the trade balance, the less there was to invest. This was why it was so tremendously important to restore that balance, and to show a more favourable margin at the end of this year than at the end of last year. This led him to refer to one matter that had been mentioned by Mr. Milne Watson. It was vitally important, whenever they were considering the use of any commodity in this country that was made outside this country, that they should count the cost of importing it, and see whether they could not make the article themselves. It was not only that they were giving more employment in this country by using the home article.

TAR OR BITUMEN.

In the particular case Mr. Milne Watson took, they were not only helping the gas industry, but they were helping coal, which was a most distressed industry. It was not only direct employment they were giving; but if they could diminish the imports, they would be increasing the trade balance, and giving themselves more money to invest. Therefore they should think, not once, but twice before giving preference to what had to be paid for by exports over the article which could be purchased at home. "Without expressing an expert judgment in this controversy," proceeded Sir Cunliffe-Lister, "I should like, purely for the sake of information, to know whether those roads of Kent, which were, I understand, the glory of that county, and the expenditure on which was such a good investment, and which have been the precedent for many great extensions and developments throughout our land, at no small outlay of public money—whether those roads did not attain to their perfection by the use of the despised tar, and not bitumen."

Dr. CARPENTER: I have been motoring for twenty years on the Kent roads. When Sir Henry Maybury was the Engineer upon these roads (on which he was one of the first to use tar), they were model roads. There are many who can speak in support of that.

Sir CUNLIFFE-LISTER (continuing) said he did think it was of enormous importance that a decision should not be come to in a case of this kind, where public money was involved, where employment of British industry was involved, without making quite sure that they could not get, by working to specification, an article which was for the purpose about as good as the thing which they would have to pay for twice over. He hoped that this question might be considered upon its merits, and with due regard to national interests; and that they would try to act, all of them—everybody concerned—in the best interests of the trade of the country.

WORK, AND WORK, AND MORE WORK.

To resume the main theme of his argument, he quite agreed that it was vitally important to-day that people should face facts; and he believed that really they wanted to be told the naked truth. He did not think they desired any concealment. They should have the courage to give British people and British industry the true facts. In every industry both parties were prepared to face facts with all the cards on the table. Difficult as the position was to-day, he was optimist enough to believe in the enterprise, initiative, and capacity of the British people—to believe that they could surmount all their obstacles. The Government would help in every way it could; but there were strict limits to what the Government could do. It could work for settlement abroad; but if stability abroad was important, more important still was settlement at home. It was necessary to avoid "stunts" and costly short cuts, and to study markets. "We have," Sir Cunliffe-Lister concluded, "the best raw material in men that any country has got. We have got to-day throughout our universities as good a training as you can find anywhere else for these men. Let us use those assets. Experience we have; credit we have, second to none. Quality, financial ability—tremendous assets for any industry and any country. Let us make the most of them. In a word, it comes back to what Mr. Milne Watson said—the greatest need for all is work, and work, and more work. We want goodwill and confidence, individual enterprise, and initiative, and at the same time everybody playing for the side." [Applause.]

KINDRED INSTITUTIONS.

Dr. CHARLES CARPENTER submitted "Kindred Institutions." He said he remembered fifty years ago his chemistry master and his old friend disabusing him of the idea that there was much honour to be attached to membership of learned societies. He said then that there was only one to which membership could not be obtained either by purchase or by favour. In the

half-century which had since elapsed, many changes had come about; and he thought they owed a great debt of gratitude to the parent society—to the Institution of Civil Engineers—who had so long lived up to that high ideal of membership as the result of examination. In other words, the application of a test to those desirous of passing through its portals. He was sorry, therefore, to find that his dear old friend the President of the Institution of Civil Engineers was not with them, so that some acknowledgment might have been made of the great work at which he had assisted in this direction. He (Dr. Carpenter) thought they might also take the opportunity of expressing their condolence at the lack of respect which the average public, the average press, and he might say the average authorities, gave to the leadership of the Institution of Civil Engineers. He could not think of any other civilized community among whom less regard was paid to the specialized knowledge of professional men than in this country. The fact of the matter, he thought, was that there were far too many amateur opinions being advertised to-day, to which a certain amount of weight and notoriety were being attached. For the President of the Institution of Civil Engineers they had an admirable substitute in their old friend Sir Dugald Clerk, to whom the gas industry owed a great debt of gratitude for the manner in which he had, clearly and fairly, set out the pros and cons of the coal question as applied to the distribution of energy. His only regret was that this work was not more widely known, or that the great store of facts was not more often drawn upon. They had also with them Mr. W. H. Patchell, representing the Institution of Mechanical Engineers. The foundation of the gas industry was mechanical engineering. It was by the knowledge of mechanical engineers that the business of gas making had been developed. It was perfectly true that now they called in more and more the assistance of the chemist in working out those problems the solution of which was so essential to their development; but even then the business was largely a question of mechanical engineering. They therefore owed very much to the Institution of Mechanical Engineers.

Sir DUGALD CLERK (Past-President and honorary member of the Institution of Gas Engineers, and Past-President of the Society of British Gas Industries), on behalf of the Institution of Civil Engineers, and Mr. W. H. PATCHELL (Past-President of the Institution of Mechanical Engineers), acknowledged the toast. The latter remarked that there was one man in the room—Mr. F. W. Goodenough—who had done more than anyone else in this country to make consumers realize that they were getting service.

THE VISITORS.

Mr. SAMUEL TAGG proposed "The Visitors;" remarking that if there was one lesson the war had taught them it was the value of publicity. With the growth of the gas industry, it had come to be realized that it was one of the essential industries of the country. It was dependent on other industries, and it was also dependent on securing the support of the community—support which could only be based on a knowledge of the work it was doing. Therefore they welcomed the presence of visitors with them that day.

Major-General Sir R. H. LUCE, replying, said he was glad to have an opportunity of telling them how much they appreciated Mr. Bell in Derby—not only as a first-rate gas engineer, but as a citizen who took the greatest interest in the town. Certainly they had a most excellent gas service. As a member of the Town Council, too, he put in very good work.

Mr. REGINALD G. CLARRY, who also replied, said he did not really regard himself as a visitor, but more as enjoying a happy re-union with some very old colleagues. His letter-bag told him that there was a great deal of apprehension in the gas industry as to what might take place in the future in the matter of State pampering of the rival industry. It seemed to him that the anxiety was justified; and it was better that anxiety should be manifested now than after legislation had been passed. Reference had been made to low-temperature carbonization. Though this was not at the moment what one might regard as a commercial proposition, yet developments were taking place. He would advise gas engineers to keep closely in touch with all developments of low-temperature carbonization of coal—particularly from the national point of view of the production of oil. Oil could be produced from coal by various processes; and he thought the right place for doing it was at the gas-works. ["Hear, hear."] If at the birth of electricity the gas industry had taken the view that the right place for its production was at the gas-works, the minds of the members would not have been filled with the anxiety that occupied them at the present time. The gas industry had rendered great service, and had a bright future before it; but whatever they did, they must not hide their light under the bushel of public misapprehension. They must let people know what they stood for—that the gas industry was the greatest industry for the conservation of coal—and then he felt sure they would maintain in the future the excellent record that they had set-up in the past.

AT DERBY—THE PRESIDENT'S HEADQUARTERS.

On Friday morning, just before 9 o'clock, the majority of the large contingent of *congressistes* and their wives assembled at St. Pancras for the last social event of the week—the visit to their President's town and its beautiful countryside, and enjoyment of the hospitality of the Chairman and Directors of the Derby Gas Light and Coke Company. The train was a "Wembley Special," and the accommodation thereon and the attendance provided left nothing to be desired. The two-and-a-half-hour journey was soon over, and the visitors found themselves marshalled into waiting tramcars, which conveyed them to the selected one of four destinations—the locomotive works of the L.M. & S. Railway, the carriage and wagon works, the gas offices and Cavendish Street Gas-Works, or the Royal Crown Derby Porcelain Works.

At the locomotive works there was a wealth of interest—the boiler and firebox plating and testing, the forging of link-motion parts, the erecting, and the immaculate painting and many other of the processes which combine to make the modern locomotive the thing of beauty which it is. At the carriage and wagon works it was difficult to imagine that the trade barometer is at its lowest, for they are turning out some 200 wagons a week, and the carriage shops are full. The rough tree sections were passing into the Canadian mill at one end, and the machined and fitted parts of wagons were being delivered in a continual stream at the other end; the sawn planks being subjected to a multiplicity of processes at almost incredible speed—such is the effect of intermediate mechanical handling and workman on piece rates! At the Royal Crown Derby Works the party, mostly ladies, evinced the keenest interest in the skill and precision which produce the world famous porcelain. They were surprised to learn that a piece is at least six weeks in the making, and that it is six times fired for 60 hours, to fix the beautiful colours which characterize it.

As for the works, offices, and showrooms of the Derby Gas Light and Coke Company, we must refer our readers for a description of these to the reprint of the handsome souvenir brochure and illustrations on page 956. In selecting our ticket for the visit, we noticed that it was planned to proceed from the carriage works to the Litchurch Gas-Works; but time did not permit of this, and several of the party were disappointed not to see certain installations—among them the new sulphate plant by the Chemical Engineering and Wilton's

THE PARTY WHICH VISITED THE LOCOMOTIVE WORKS.

Patent Furnace Company. This embodies several novel features, and the Engineer of the station, Mr. Fisher, is entertaining great hopes of its working.

The Luncheon.

The luncheon offered by the Derby Gas Light and Coke Company was served in the Drill Hall, as the Assembly Rooms, which were originally intended for the function, could not accommodate the exceptional number who accepted the invitation. No fewer than 390 sat down to a luncheon which was excellently served.

Mr. William Woolley (Chairman of Directors), with whom was Mrs. Woolley, presided; and with him at the table of honour were: Alderman W. Hart, Lt.-Col. G. A. Strutt, Mr. E. S. Johnson, Mr. M. Attwood (Directors); Mr. and Mrs. J. Ferguson Bell, Mr. C. F. Botley (President-Elect) and Mrs. Botley, Sir Albert and Lady Ball, the Lord Mayor of Manchester (Alderman F. J. West) and Miss West, Sir Henry Fowler, K.B.E. (Deputy Chief Mechanical Engineer, L.M. & S. Railway) and Lady Fowler, Mr. J. H. Follows, C.B.E. (Chief General Superintendent, L.M. & S. Railway) and Mrs. Follows, Mr. Frank Tatlow (late General Manager of the Midland Railway) and Mrs. Tatlow, the Mayor of Halifax, the Mayor and Mayoress of Derby (Mr. and Mrs. Allen Mycroft), Mr. G. Trevelyan Lee (Town Clerk), Dr. Brindley (Medical Officer of Health), Mr. J. W. Horton (County Surveyor), Dr. Laurie,

Mr. Bell Chatting to Mr. J. H. Follows, C.B.E., Chief General Superintendent of the L.M. & S. Railway.

Mr. and Mrs. Thomas Hardie, Mr. and Mrs. W. Doig Gibb, Mr. and Mrs. Madden, Mr. John Peacock, and Mr. W. Moore (President of the Derby Chamber of Commerce).

The Loyal Toast having been duly honoured, Mr. William Woolley rose to say that he had been pressed for a few words, although it had been arranged that there should be no speech-making. He was content to feel that by their very presence their guests thanked the Derby Gas Light and Coke Company for the entertainment. The Directors were exceedingly glad to welcome them, and it had been a real source of pleasure to do so—to know each other better—for they were all interested in one particular industry. He trusted that they had learned something from their visit to Derby Gas-Works, and to the great works of the L.M. & S. Railway, of which Derby was so proud. He felt sure that, when they departed that evening, they would carry with them the same high opinions as they had freely expressed that week in London of the Chief Engineer of the Company.

Chatsworth.

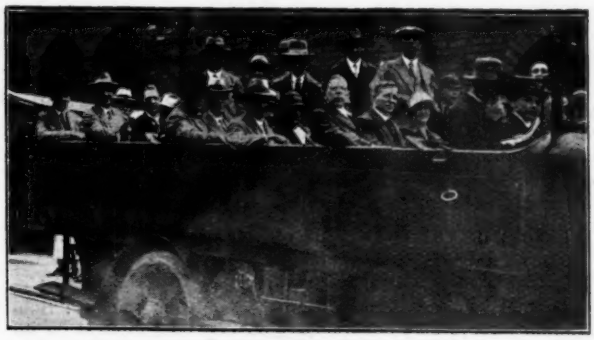
The afternoon drive was to have been to Haddon Hall, but owing to the regrettable fire which recently destroyed the tea-rooms and other parts of the property, the arrangements had to

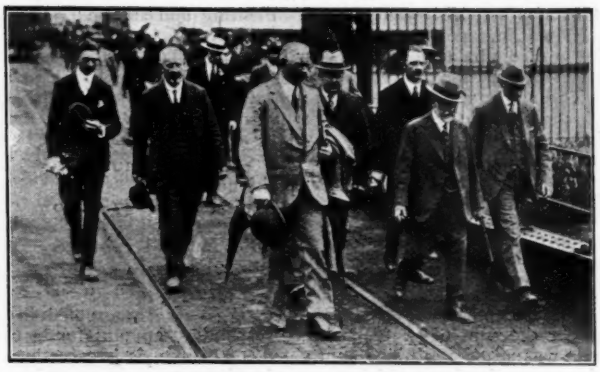
MR. WILLIAM WOOLLEY.
Chairman of the Derby Gas Light and Coke Company.

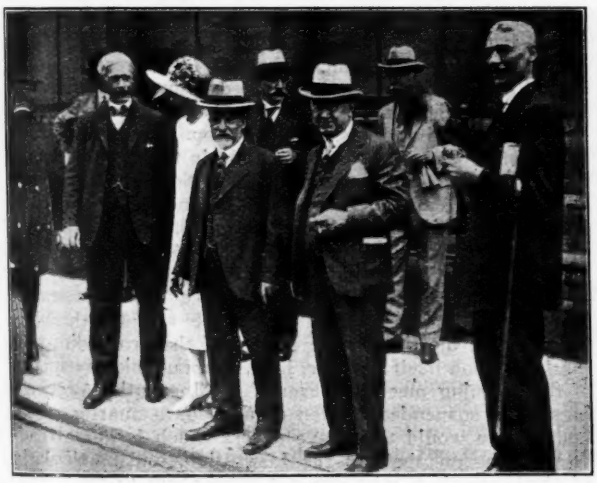
be altered; and by the courtesy of the Duke of Devonshire, an intellectual and æsthetic treat was provided in the form of a visit to Chatsworth. The brilliant weather of the week held out, though a storm was threatening and there was a heat mist which impaired the view of this beautiful countryside. Highly qualified guides explained as much about the wonderful treasures of Chatsworth as time would allow; and then the motor coaches took us to Bakewell. Thence the special train journeyed to Derby, and then to London; and thus closed a memorable day.

One thing must not be forgotten—to record the gratitude which was everywhere expressed for the hospitality of the Derby Gas Light and Coke Company and the infinite pains which Mr. Ferguson Bell, his assistants, and staff must have taken in organizing the details of the excursion and looking to the comfort of everybody. In this regard we would specially mention Mr. Harry Clark, the Distribution Superintendent, which brings to mind that the Derby Company have this year provided a President not only for the Institution of Gas Engineers, but for the Midland Junior Gas Association, a fact of which they are duly proud.

MR. H. BULLIVANT, F.C.I.S.
Secretary to the Derby Gas Light and Coke Company.







LEFT TO RIGHT: Mr. C. F. Botley, Miss Bell, the President, Capt. H. M. Haywood (Chief of Police, Derby), Mr. W. E. Price, Mr. E. S. Johnson, Mr. W. T. Dunn.

LEFT TO RIGHT: The Mayor of Derby, the Lord Mayor of Manchester (Alderman Fred. West), Sir Henry Fowler, K.B.E., and the Misses Bell.

A LINK WITH THE PAST.

An interesting letter, including the following statements, has been addressed to the British Empire Gas Exhibit Committee by Mrs. Clara Branson, who before her marriage was Miss Heard:

> I trust you will pardon the liberty I have taken in addressing you; but I have been deeply interested in the reading of the statements made concerning the "Spirit of Coal," gas, in the Palace of Industry at Wembley—shown as a world-wide servant—and the benefits it renders in the home and in business. It plays a great part in providing the necessities, utilities, and luxuries of modern life, and in one-hundred-and-one purposes of domestic use.
>
> You may be interested to know that I am still living—a link with the past—at the age of 81, and am a daughter of Edward Heard, a practical chemist, who did such noble work, which has benefited the public life up to the present moment of time—he being the original discoverer of the purification of gas, which he patented in 1806. He was engaged by a Mr. Winsor, in the year 1804, to deliver lectures in the Lyceum Theatre in London, on "The Application of Coal Gas to the Purposes of Artificial Light." After a series of experiments, he discovered the cause of the offensive odour which (and its irrespirability) rendered coal gas unfit for domestic use; and having proved its efficacy, he took out a patent. This passed the Great Seal in June, 1806, he having been allowed six months to specify, which specification I still have in my possession, with other papers concerning it. It can be seen at any time.
>
> Some years ago my mother received a visit from Mr. Walter King, of Bolt Court, and Mr. Thomas Berridge, Gas Manager at that time at Leamington, who could (were they living) vouch for the truth of what I assert, and kindly placed a stone upon her grave at Kenilworth.
>
> I have given a brief note of a great service rendered to mankind; and although there have been progressive strides in connection with the said discovery, it still lives, and is appreciated in the world as one of the great masterpieces of science.

INSTITUTION BENEVOLENT FUND.

The Annual General Meeting of the Benevolent Fund was held on Wednesday morning, the attendance being very small. Mr. J. FERGUSON BELL was in the chair.

The minutes of the previous meeting were read and confirmed.

The HON. SECRETARY then read the following.

REPORT OF THE COMMITTEE OF MANAGEMENT FOR THE YEAR 1924–1925.

The income for the year ended Dec. 31, 1924, amounted to £534 10s., and was derived from the following sources: Subscriptions, £272 4s.; donations, £89 12s. 8d.; interest on investments, £138 16s. 2d.; interest on deposit account, £3 3s. 10d.; and recovery of income-tax, £30 3s. 4d.

In assistance to widows, orphans, and aged members the sum of £489 18s. was granted. Printing and stationery cost £31 0s. 6d.; postage, receipt stamps, &c., £7 14s. 7d., leaving a credit balance for the year of £5 16s. 11d. (as against a credit balance for the year 1923 of £236 4s. 9d.).

The response to the special appeal issued by the President of the Institution, Mr. J. Ferguson Bell, has resulted as follows:

New annual subscriptions	£10	3	6
Special contributions, or additional to annual subscriptions	47	11	0
Donations (including donation per the Redditch Gas Company of £25) ...	41	5	6
	£99	0	0

The Committee have already, for the year 1925, voted in grants the sum of £517. The corresponding amount for last year was £489 18s. The sum voted, of course, is irrespective of any applications which may arise from new cases which may come in.

Indeed, just as this report was being prepared, a fresh application for assistance was received from an aged former member of the Institution, in response to which the Committee are voting the sum of £20.

A copy of the accounts for the year 1924, compared with those for the previous year, duly audited by Mr. S. Y. Shoubridge and Messrs. Wood, Drew, & Co., has already been issued to every member of the Institution.

The two members of the Committee retiring by rotation after the usual three years of service are Mr. Ralph E. Gibson, of Liverpool, and Mr. E. George Hutchinson, of Westgate-on-Sea. To serve in their places the Committee have nominated for election at the annual meeting of the contributors Mr. Ralph Halkett, of Sheffield, and Mr. C. S. Shapley, of Leeds.

The PRESIDENT: You have heard the Report of the Committee for the past year, and I think you will agree that on the whole it is eminently satisfactory. I should like again to express my thanks to those members who were good enough to respond to my appeal, which resulted in an immediate increase in the funds of £99. As I intimated yesterday, the Lord Mayor of Manchester has been good enough to say that he will give a donation of £100, and that is also to the good. This Benevolent Fund does an enormous amount of good work. We received only two or three weeks ago an application from one of our aged members who is in the infirmary and has had an operation; and the result was that we decided to send him at once £10 and a further £10 later on. We could multiply these cases almost innumerably, where the assistance given through the Fund has made all the difference between living reasonably and being on the verge of starvation. The Fund was established so that those who suffer from reverses through no fault of their own, or the dependants of those who are unfortunately taken away, may be assisted. I do not think there is any more beneficial fund of the Institution than this one, and I am extremely glad to know that the members of the Institution are realizing the good work the Fund is doing and that subscriptions are being increased. I would, however, like to emphasize this point. It is not every member who can give large sums, but all can give from 5s. upwards, and I should be extremely glad if every member of the Institution will say "I am going to be a subscriber to the Fund, even if it is only a small amount." The Evening Star Lodge, which generally holds an Emergency Meeting on the Monday evening before our meeting, have in their Charity Box subscribed £14 2s. 6d. I am sure that I am voicing the opinion of the members in saying that we are extremely obliged to them and to the other donors for their great assistance.

Mr. SAMUEL GLOVER: I should like to thank the Chairman for his kindly explanation of the position of the Fund. When the Secretary was reading the Report, he said that a sum of £20 had been given in a recent case, but the Chairman in the course of his remarks showed how this £20 is being given in a somewhat unusual manner. We as members are very glad to know that your kind heart and the kind hearts of those who with you have been looking after this Fund for us, has been warmed towards the work you are able to do in this manner. I know, Mr. Chairman, the very warm place which this Fund has in your heart, and how glad you are that the engineers who are able to do so subscribe to it, and so enable this good work to be carried on for the benefit of those who are in need. I hope that the Fund will continue to prosper. Perhaps I might ask how the £100 from our new honorary member, the Lord Mayor of Manchester, is to be disposed of. You said it was given as a donation, and I should like to know that it will be placed to capital account and will be treated as a source of income for the Fund and not be disposed of in grants. I again thank the Chairman for his very helpful review of the situation, and I have much pleasure in moving that the Report be adopted.

The CHAIRMAN: With reference to the £100 donation from the Lord Mayor of Manchester, at the meeting of the Benevolent Fund Committee this morning it was decided to invest it in War Bonds, so that about £5 a year will come in as income to the Fund.

Mr. WATSON: I should like the privilege of seconding the motion, and I do so with sincere feelings, because I appreciate the help the Committee have given in a case in which I have been interested during the past few months; and I know how much the grant which the Committee have given in that case will be appreciated. This is the second case in which I have been interested, and I do not think I have ever appreciated so much the peculiar necessities under which a past member of the Institution has been placed and has benefited from the Fund. I feel sure that, if such cases were brought in the abstract to the notice of the members of the Institution generally, we should get greater help, perhaps, than we are getting. In this connection I would like to make a suggestion. I do not know whether it will meet with the views of the Council of the Institution of Gas Engineers; but in view of the scanty attendance that we have here this morning, it occurs to me that it might be well worth while holding this meeting in the middle of the proceedings of the Institution itself ["Hear, hear"] about midway in one of the morning meetings, even if the Institution proceedings were suspended for ten minutes or a quarter of an hour. You would then have a very much larger attendance of the members of the Institution, and particularly of those members who are not subscribers to the Fund. I have much pleasure in seconding the motion for the adoption of the Report.

The CHAIRMAN: The report is now open for discussion.

As there are no comments, I will only say that since I entered the room this morning I have received a donation of £1 from Mr. M'Lusky, of Halifax, bringing the result of the Special Appeal up to £100. [Applause.]

The report was adopted.

The CHAIRMAN: We have now to appoint a Trustee in the place of the late Mr. H. E. Jones. The Committee looked round to see who would be the right gentleman to nominate; and there occurred to me the Governor of the Gas Light and Coke Company (Mr. Milne Watson), who is also President of the Gas Council, and, as you know, is very actively associated with all that concerns the gas industry. I approached Mr. Milne Watson, and asked him if he would be good enough to take Mr. Jones' place, and he said that, if it were the wish of the members, he would be very pleased to do so. I brought that before the Benevolent Fund Committee, and they unanimously agreed to ask Mr. Milne Watson to be Trustee. Mr. Dunn communicated that decision to Mr. Milne Watson, and he has written expressing his pleasure in accepting the nomination.

On the proposal of the CHAIRMAN, seconded by Mr. SAMUEL GLOVER, Mr. Milne Watson was unanimously elected a Trustee.

The CHAIRMAN then announced that Mr. Ralph Halkett (Sheffield) and Mr. Charles S. Shapley (Leeds) had been elected by ballot to succeed Messrs. R. E. Gibson (Liverpool) and Mr. E. G. Hutchinson (Westgate-on-Sea), who retire by rotation.

This closed the Benevolent Fund meeting.

EDUCATION SCHEME.

REPORT OF THE ADVISORY COMMITTEE FOR THE YEAR 1924-25.

Adopted by the Committee, May 12, 1925.

The year 1923-24 was fittingly described as a year of foundation laying. That of 1924-25 may be spoken of as one of steady, painstaking building. Brick has been added to brick, and a structure is beginning to take shape. Progress has been slow, but it is hoped all the more sure because of the care taken. Last year it was possible to report only 11 centres at which organized instruction in gas subjects was being given. This year the number has increased to 21 (as per list appended), while there are two other centres at which the earlier parts of approved courses are being taken.

Other applications for the approval of Courses of Instruction are known to be pending, so that it is hoped that the list may be extended in time for the session of 1925-26.

Last year, only 4 centres were in a position to present students for examination. This year 54 candidates are coming up from 8 centres.

The number applying for examination shows a gratifying increase in regard both to external and internal candidates.

The comparative figures are :—

	1923-24.	1924-25.
Internal Students ..	... 36	... 54
External Students ...	... 24	... 56
	60	110

Having regard to the increased number of centres at which courses under the Institution Scheme are now being taken, and to the fact that this will be the last year in which the educational work of the Institution and that of the City and Guilds of London Institute will overlap, it may be anticipated confidently that next year the numbers applying for examination under the Institution Scheme will be considerably increased.

An illuminating side-light on the great need there was for the Institution to take up this work is afforded by the fact that no less than 30 applications to sit for examination had to be refused owing to the students' lack of preliminary scientific training. The fact of these applications being made reveals a desire, on the part of the students, for the advantages the scheme confers, while it is most unlikely that so many would have had to be refused for the present had a satisfactory education scheme been in operation for a longer period.

In considering the applications in question, the Committee has been anxious to deal as sympathetically as possible with every case on its merits, while on the other hand maintaining the high standard which the times and the industry demand. It is satisfactory, therefore, to note that the decisions of the Committee in those cases, unwelcome as they have naturally been, have been loyally accepted, and that the students have seriously set themselves to repair those defects in their fundamental training which have been pointed out to them.

The year has been marked by several outstanding features of interest. It is gratifying to report that both the Ministry of Education for Northern Ireland and the Department of Education for the Irish Free State have accepted the scheme, have appointed representatives to the Central Advisory Committee, and have signified their willingness to co-operate in every way in applying the scheme in their respective areas of administration.

A development of great promise for the smooth working of the scheme is the appointment of Committees of Advice for both Wales and Scotland. These are intended particularly to assist and advise as to his best method of procedure the student who is situated at a distance from educational centres. Moreover, courses of instruction vary so much in the Technical Institutes and Science Schools of the United Kingdom that students are often in considerable doubt as to the best plan of study in their particular circumstances. These local and personal difficulties can undoubtedly best be solved by those familiar with the precise circumstances and conditions which give rise to them; and it is hoped that these Committees of Advice in Wales and Scotland will be appreciated and utilized by many students.

It is with satisfaction we report that a liaison has now been established between the educational work of the Institution and that of our Universities. A graduate possessing an approved degree in Gas Engineering taken in a British University is now exempt from the written portion of the Diploma examinations, but is required to submit a thesis, present himself for oral examination, and satisfy the Advisory Committee as to his professional experience.

Reference has been made to the elimination of the overlapping of the Institution's Education Scheme with the work of the City and Guilds of London Institute. This has been made possible by the thorough revision of the whole of the work of technical education within the industry. As a result of an interview between the Advisory Committee and representatives of the City and Guilds of London Institute, a Committee was set up to consider the whole question. This resulted in—

1. The adoption of a grouped Course for Gas Fitters;
2. The establishment of what have been designated Minor Grouped Courses in (*a*) Gas-Works Practice, and (*b*) Gas Supply Practice, for those unable or not desiring to take the "professional" Courses of the Institution Scheme.

In the establishment and operation of these courses—whereby the Education scheme has been extended so as to provide for all grades of those engaged in the industry—the Advisory Committee and the City and Guilds of London Institute are working in the closest co-operation. Complete syllabuses have been drawn up, and are now embodied with the particulars of the "Major" Courses in the Regulations issued by the Institution, copies of which may be obtained on application to the Secretary, 28, Grosvenor Gardens, Westminster, S.W. 1. The value of the certificates gained in connection with the "Minor" Courses will be considerably increased through their being endorsed by the Institution.

It was with great regret that early in the year the Committee received the resignation, owing to ill-health, of Mr. J. Wesley Whimster as one of the Examiners in Gas Supply. It was at the same time decided to increase the representation of the North on the Board of Examiners by the addition of another member. Mr. George Keillor, of Greenock, and Mr. R. B. Roxburgh, of Newcastle-on-Tyne, were therefore elected to fill the vacant positions.

APPENDIX.

LIST OF SCHOOLS AND COLLEGES GIVING "COURSE" INSTRUCTION UNDER THE SCHEME OF THE INSTITUTION OF GAS ENGINEERS.

Bath Municipal Technical College.
Barnsley Technical School.
Birmingham Municipal Technical School.
Coventry Technical Institute (For early years of Course only.)
Wolverhampton Technical College (For early years of Course only.)
Blackburn Municipal Technical College.
Bournemouth Municipal College.
Bradford Technical College.
Bristol: Merchant Venturers Technical College.
Burnley Municipal College.
Coventry (see Birmingham).
Derby Municipal Technical College.
Dewsbury Technical College.
Glasgow Royal Technical College.
Halifax Municipal Technical College.
Huddersfield Technical College.
Leeds Central Technical School.
London: Regent Street Polytechnic.
Westminster Technical Institute.
Manchester Municipal College of Technology.
Plymouth Municipal Technical School.
Portsmouth Technical College.
Salford Royal Technical College.
Stoke-on-Trent Central School of Science and Technology.
Wolverhampton (see Birmingham).

The PRESIDENT: I have the very greatest pleasure in asking our good friend Mr. Goodenough to present the Report of the Education Committee.

Mr. F. W. GOODENOUGH: In presenting on their behalf the Education Committee's report for the past year, I should like to call the attention of members to one or two points. First let me say that, while the Committee are glad to see the in-

crease in students presenting themselves for examination—namely, from 60 last year to 110 this year—they regard the latter figure as very far below the number they hope to see taking the examinations in years to come. One student for examination to 8 statutory gas undertakings in the kingdom—one to 14 of all the gas undertakings of the country—is a very low figure. It is certain to increase as the arrangements made for courses in Gas Engineering and Supply at the various centres get into full working order; and members will have observed with satisfaction the considerable increase in the number of centres at which such courses have been arranged. But something more than the establishment of courses at numerous centres is necessary before we can hope to get the number of young men there ought to be, throughout the country, qualifying themselves for promotion and fitting themselves for raising the standard of knowledge and efficiency in the industry. Gas undertakings everywhere should, definitely and practically, support the scheme of the Institution, adopt it as part of their own plans for building up staff, make it well known to everyone in their employment, and not only encourage, but assist, would-be students to take-up courses, both by liberal treatment in regard to travelling expenses and to time-off for attending the necessary classes, and by adequate recognition of success in the examinations. The industry needs, and as competition becomes more and more keen will more and more need, well-educated staffs—not only technicians and scientists in the works and laboratories, but also representatives with both technical knowledge and commercial capacity on the districts. Gas undertakings must create the demand for better human material by paying qualified men good salaries and by being prepared to pay still better salaries as men become better qualified. The machinery for assisting men to improve their qualifications now exists, and is being steadily improved as experience proves necessary—for we do not regard the scheme as stereotyped, but as open to amendment always. We believe the men exist who are anxious to qualify for advancement. It is for the industry to make it clear that better qualified men are wanted, and will be paid for according to value.

On this point of the men being willing or unwilling to work earnestly for their better qualification if they are encouraged to do so, I should like, if I may in passing, to enter a protest here against the sweeping attack on the present generation of young men made by Dr. Arthur Shadwell in "The Times" last Wednesday. Writing with that air of omniscience and authority so often assumed by the literary onlooker (who by no means always sees most of the game of business, because he has never played it, and knows little of those who do), Dr. Shadwell roundly states that "there is really something wrong with the present generation; they neither work well nor play well. They seem altogether lacking in energy and serious purpose. . . . And this holds good," he adds, "of all classes; they are all crazy for amusement and show."

Well, I am sure you will agree with me that it simply is not true that our young men neither work well nor play well. Of course they are not all paragons of virtue and diligence; but when we have large numbers of men working for us who are ready and willing to give up three at least and often more evenings a week to attend science and other classes, and travel considerable distances to do so, and many more are constantly putting in long hours on their companies' work without a murmur—keen on their business and on their studies, as well as keen on their sports—it makes one resent warmly such superficial criticism as that I have quoted.

And we in more responsible positions are regarded as decadents unworthy of our forebears, because we play golf on Saturday mornings—sometimes—or go away for the week-end on Friday nights. If some of our arm-chair critics could realize how the labour-saving machinery of modern business life has increased the hourly output of nervous energy by those in administrative positions, they would hold their tongues, or talk sense. Very few people probably realize the extent to which the telegraph, the telephone, the shorthand-typist, the dictaphone, the motor car, have combined to make it possible for a manager to-day to do actually three times as much work in an hour as could his most diligent grandfather, and how in so doing he uses up so much nervous energy as to make it imperative that he should have longer time for re-creation (using the word in its truest sense) than was necessary for the manager working at the lower pressure of former days.

This digression is, I suggest, not altogether irrelevant to my task of presenting our report on Education. If the present and future generations are both to work well and to play well, as we believe they wish and are prepared to do, and to carry this great industry through present contests to future victories, and to increase its power of serving the nation with satisfaction and profit, they must be given every encouragement to get themselves well educated under conditions that do not put upon them too great a nervous strain. We of the Committee are therefore anxious to arouse fully the interest, and enlist fully the help, of every member of the Institution in the steps that are being taken to make it possible for every man to get the education he needs.

This brings me to two other points we desire to stress. The first is that, to make the Institution scheme meet the needs of as large a number as possible of the men in the industry who feel the desire for further education, we have organized, and added to the scheme, what are called the "minor grouped courses" in Gas-Works Practice and Gas Supply Practice. These are designed mainly to fit the needs of those (and there are many) in the industry who do not aspire, or who are not able, either to become professional men of such knowledge and experience as would enable them to obtain Higher Certificates or Diplomas in Gas Engineering or Supply, or craftsmen as highly qualified as those able to pass the practical examinations in gas fitting, yet are keen to demonstrate that they possess a good general knowledge of the practical operations of the industry in which they are employed, and are thereby better qualified to perform the duties on which they are engaged, whatever those duties may be. We believe that by thus providing for three general categories of students—who may be classified as (*a*) professional men, (*b*) craftsmen, and (*c*) those who are neither the one nor the other, but should understand the operations of both—the scheme has been considerably improved; that it will draw to itself an increased number of students; and that it will secure the active interest and support of an increased number of the boards and committees, as well as managers, of gas-works throughout the country.

The other point we wish to emphasize is that we have done, and will do, everything we possibly can to make the scheme available for every man in the industry who desires to take advantage of it; but that our desire so to do must always be governed and limited by the paramount need of maintaining such a standard of study and instruction required from every student as shall ensure that the possession of certificates and diplomas granted by the Institution and endorsed by the Board of Education shall testify beyond doubt that the holders have reached definite standards of knowledge, training, and experience. Employer and employed alike must be able to feel confident that a certificate or diploma means, and is known to mean, something definite and practical in relation to the holder; or the scheme will fail of its prime object. So clear are the Committee on that point, so certain are they that, in maintaining—and, in the course of time, raising—the standard of value of the certificates and diplomas, they have the full support and mandate of the members of the Institution, that they are obliged to have that consideration always in mind in adjudicating upon the qualifications of students to sit for examination. Especially in these early days of the working of the scheme, the Committee are anxious to err, if they err at all, in favour of the would-be candidate; and they have accepted some on the border line who in later years they would certainly reject. This is what they desire that all members should know; and they desire to say that no one more regrets the refusal of admission to examination of a student than they do. The value of the certificate, however, now and in the future, must always be the prime consideration.

Those who represent the Institution on the Committee desire to put on record their great appreciation of the assistance rendered to them so readily and generously at all times by the members representing the Education Authorities. Those representatives could not be more devoted to the service of the scheme if they were actually engaged in the industry; and their knowledge and experience are invaluable. Finally, let me say that all members of the Committee appreciate, as I am sure all members of the Institution appreciate, the work done by the Board of Examiners, whose task is neither easy nor light, and who perform it in a spirit beyond praise—words equally true of our Organizing Secretary, Mr. Walter Hole, who lives for the scheme and for those it is designed to assist, and who spares neither time nor energy in its service.

I beg to move the adoption of the report.

Mr. Samuel Tagg: I have very great pleasure in seconding the adoption of the report. I need say nothing more than endorse the appeal which the Chairman of the Committee has made for the support and co-operation of the engineers and undertakings throughout the country to make for the proper utilization of the scheme which has been prepared and which has been designed, as far as possible, to meet every conceivable condition which obtains in different parts of the country. I should also like to endorse his reference to the invaluable work of the members of the Education Authorities on the Committee. I think there is no Committee of the Institution which has done more work than the Education Committee.

The President: The report is now open for discussion. I am sure we of the Institution feel very much indebted to the Education Committee—and especially the Chairman—for the great amount of work which they have put into this scheme. It is for the members of the Institution to show their appreciation of the work which has been done; and you can best do this by getting those connected with your undertakings to take advantage of the scheme. It is absolutely necessary, if we, as an industry, are to maintain our position, to have men trained technically; and this scheme has been thought out, as I mentioned in my Address, with this object in view. It is receiving the support of the various Education Authorities, and I do hope that members will support the scheme as it really deserves. The opening remarks of the Chairman of the Committee, Mr. Goodenough, have so completely covered the ground that it seems there are no questions to be asked.

The report was adopted.

THIRTEENTH REPORT OF THE RESEARCH SUB-COMMITTEE OF THE GAS INVESTIGATION COMMITTEE OF THE INSTITUTION OF GAS ENGINEERS.

I. AERATION OF LIGHTING BURNERS. II. DETERMINATION OF SPECIFIC GRAVITY OF GASES.

Adopted by the Gas Investigation Committee, May 21, 1925.

RESEARCH SUB-COMMITTEE.

Chairman: Emeritus Professor Arthur Smithells, C.M.G., D.Sc., F.R.S., Director of the Salter's Institute.

Representatives of the University of Leeds: Professor J. W. Cobb, C.B.E., B.Sc., F.I.C. (Honorary Secretary), Emeritus Professor J. B. Cohen, Ph.D., D.Sc., F.R.S., Mr. G. R. Thompson, B.Sc. (One vacancy.)

Representatives of the Institution of Gas Engineers: Messrs. J. Bond, O.B.E., T. Glover, C.B.E., M.Inst.C.E., H. Pooley, M.Inst.C.E., S. Tagg, M.Inst.C.E., and C. Wood, O.B.E. Mr. C. S. Shapley was co-opted a member of the Research Sub-Committee for the purpose and period of research work at the Leeds Gas-Works.

Research Chemists: James W. Wood, M.Sc. (Tech.), A.I.C., A. Parker, D.Sc. (Birmingham), M.Sc. (Manc.), F.I.C.

Research Assistants: H. Kerr, A.I.C., Diploma Fuel and Metallurgy (Leeds), G. B. Howarth, M.Sc., Gas Engineering (Leeds), A.I.C., and A. C. Monkhouse, Ph.D. (Leeds), B.Sc., A.I.C.

INTRODUCTION.

The constitution of the Gas Heating, Lighting, and Ventilation Research Committee has not changed during the year, and it has continued to act under the Chairmanship of Professor Smithells as the Gas Research Sub-Committee of the larger Gas Investigation Committee.

Work has been continued under the supervision of Professor Cobb in two main branches for which Mr. J. W. Wood and Dr. A. Parker have been immediately responsible. All the work this year has been carried out at Leeds, partly in a laboratory provided by the Leeds Gas Department at the Meadow Lane Gas-Works, and partly on the new Corbet Woodall Experimental Gas Plant now attached to the Department of Coal Gas and Fuel Industries at the University.

The principal work to which Mr. Wood, assisted by Mr. G. B. Howarth, has given up his time has been a continuation and development of those studies in the aeration of burners by injection which have already formed the subject matter of the 9th and 11th Reports. It may be recalled that after a certain amount of general preliminary experimental investigation had been carried out, some typical heating burners of the types used in ring burners and gas fires were examined, their behaviour under deliberately varied conditions of operation being studied and summarized. Then came the turn of the lighting burners, upright and inverted, and the careful investigation made of these during the past twelve months forms the subject matter of the 13th Report (Part I.). The methods of testing had to be modified because of the comparative compactness and delicacy of construction of the lighting burner, and the necessity for making all measurements with the very minimum of interference with the delicately balanced streams of gas which had to be examined.

A number of interesting points emerged which can be found in the report. We have again adhered to the plan of placing in the forefront of each report a special introduction explanatory of what was projected and a summary of the principal results obtained.

An interesting deduction made from a large number of observations was that the degree of aeration by primary air obtained in an ordinary lighting burner, working normally and satisfactorily, was less than half that necessary for complete combustion. This indicates the high order of importance attaching to the construction of those parts of the burner and its accessories which influence the supply of secondary air, which must be made effective if good illumination is to result.

One of the factors of primary importance in aeration is the specific gravity of the gas which determines its injecting power, and it has been plain for some time that for the better information and equipment of the gas industry it was advisable to place the experimental determination of specific gravity on a better footing. Some careful work has been carried out in this connection, and it has been shown that, if properly installed and used, apparatus described by Blackie (Fuel Research Board Report, No. 5) can be operated with great accuracy and reasonable celerity. The necessary precautions and corrections are indicated (13th Report, Part II.).

Notes have been prepared too by Mr. Wood and Mr. Howarth embodying the experience of the Research Staff during the last seven years, on some important points in accurate gas analysis, and these have been put forward in an appendix.

Dr. Parker and his assistants have been occupied in getting the Corbet Woodall Experimental Gas Plant into a proper condition for the carrying out of reliable experimental work by its use, and in the making of preliminary tests. This has necessitated careful study of detail and some modification of the plant. A description of what has been done is published in the 14th Report to serve as a record in the Transactions of the Institution of Gas Engineers of the form taken by this important addition to the equipment of the University of Leeds.

The Committee would like to acknowledge its indebtedness again to Mr. J. W. Wood and Dr. A. Parker, the Research Chemists in charge of the two branches of its work now reported upon, for the continuing zeal, ability, and initiative which they have brought to bear upon the work committed to them, with the valuable aid rendered by Mr. Howarth as assistant to Mr. Wood, and by Mr. Kerr and Dr. Monkhouse as assistants to Dr. Parker. The opportunity is also taken of thanking Mr. C. S. Shapley and the Leeds Corporation Gas Department for the greatly appreciated facilities which they have continued to provide at the Meadow Lane Gas-Works.

SUMMARY.

PART I.

1.—This report (Part I.) is concerned with the degree of aeration of a number of typical low-pressure upright and inverted lighting burners, suitable for domestic use and for street lighting.

2.—The tests have been conducted under a variety of conditions at pressures up to 4 in. water-gauge (w.g.), mainly with gases of sp. gr. 0·49 and calorific value 460-470 B.Th.U. gross per c.ft., the nitrogen content being 10 to 11 p.ct. The average total theoretical air requirement per c.ft. of gas for complete combustion was 3·9 c.ft.

3.—The curves obtained, connecting air-gas ratio and gas pressure, were all of the same general type, showing a rapid increase in aeration with pressure up to 2·5 in. w.g., above which the further increase in aeration was relatively small.

4.—The amount of air injected as primary air, when the burners were adjusted as in normal practice, was usually slightly less than half the total air required for complete combustion.

In most cases, with a pressure of 2 in. w.g. or above, this limit was imposed by the necessity of obtaining *with the gas, mantle, and burner in use,* a stable flame of suitable size and shape for yielding reasonable illumination, and not by inability of the burner to inject a greater quantity of air.

5.—The quantity of air injected in the inverted burners tested, when adjusted for best illumination with

gas of the above quality was 1·7 to 2·1 c.ft. of air per c.ft. of gas, at a pressure of 2·5 in. w.g., although some of the burners were capable of injecting up to 2·5 c.ft. of air per c.ft. of gas when the air ports were fully open. The corresponding figures were higher for the upright burner.

6.—The air-port area provided when the shutter was fully open was in no case so small as to account for a low air-gas ratio; and the degree of aeration was not proportional, even in the roughest sense, to the air-port area, after a certain size, dependent upon the design of the burner, had been exceeded.

7.—In lighting burners (as with gas rings and gas fires—9th and 11th Reports) the heating-up of the appliance when in use materially reduced the quantity of air injected as compared with the performance on first lighting-up, when the burner, gas, and air were all at room temperature. This effect was much more pronounced with lighting burners than with gas rings and gas fires, amounting at times to as much as a 40 p.ct. reduction.

8.—With an upright incandescent burner the use of a chimney exerted no appreciable effect upon the primary aeration of the burner; the improvement in aeration obtained by the use of such a chimney being apparently due to more effective secondary aeration.

9.—The discharge-pressure relations for a number of typical commercial burner nipples have been determined. They exhibit considerable variations among themselves, and over the range ½ to 4 in. w.g. deviate appreciably from the generally assumed relationship that the discharge is proportional to the square root of the pressure. For the same gas and nipple, however, and for a range of (say) 1 in. w.g. above and below a working pressure for which the discharge has been determined (say, 2·5 in. w.g.), the error resulting from the application of the usual formula would in general be less than 1 p.ct.

Part II.

10.—Much attention has been paid to the determination of the specific gravity of gases. The differential column method described in Technical Paper No. 5 of H.M. Fuel Research Board has been carefully examined. Full details are given of the instruments and the methods we have adopted, and our results show that the method is convenient, rapid, and capable of yielding results correct within ± 0·002 with ordinary town gas (sp. gr. about 0·5).

11.—A critical review is included of the methods of gas analysis adopted in the course of our investigations.

PART I.

AERATION OF LIGHTING BURNERS.

Introduction.

This report is the natural continuation of the 9th and 11th Reports of the Gas Investigation Committee, dealing with the factors which influence the amount of air injected by gas burners. It extends the investigation to cover lighting burners, both upright and inverted, of types suitable for domestic and for public lighting.

In selecting the burners to be tested, care was taken that they should be good specimens of their class, each burner representing as far as possible a commonly occurring type, with some characteristic feature either in construction or mode of operation. Careful inquiry seemed to indicate that, but for one well-known exception, the use of a fixed orifice in lighting burner nipples was declining; and most of the experimental work in the present report was conducted with variable nipples of the needle-regulated type, shown in cross-section in fig. 6. As to the relative injecting efficiencies of single fixed orifices, multiple fixed orifices, and variable nipples, we are not yet in a position to speak; but of the adaptability of the latter for use with different grades of gas, and supplies at a variety of pressures, there can be no question. The results of an examination of a number of these nipples, in an attempt to obtain some discharge characteristics, are given later in the report.

So far as reporting the results of tests is concerned, these variable nipples present a serious problem, for there is great difficulty in conveying to a reader an idea of the precise adjustment of a commercial nipple, and even the experimenter himself may have difficulty in defining or reproducing a particular adjustment, while calculations of velocities of flow, &c., of the gas stream from the nipple become almost impossible.

Unless otherwise stated, the nipples have been adjusted as follows. Upon the basis of the results given in the 1st, 2nd, and 3rd Reports of the Gas Investigation Committee, there was selected for each burner a certain thermal rate which might be expected to yield a reasonable illuminating power and thermal efficiency. Knowing the calorific value of the gas, it was a simple matter to deduce the corresponding gas rate; and it was further agreed that the nipple should be adjusted to deliver this quantity with a pressure of 2·5 in. w.g. immediately behind the regulating needle. A margin of ± 5 p.ct. was allowed on this initial adjustment, because slight changes in gas quality, specific gravity, temperature, and barometric pressure would have rendered adjustment to a precise rate most difficult, and it is doubtful whether any particular advantage would have been obtained thereby. The nipple thus adjusted was then used for a series of aeration tests at different pressures without being further disturbed—*i.e.*, for the time being it became a "fixed orifice" of a particular design. This group of tests indicated to what extent further adjustment might be necessary to secure satisfactory behaviour of the burner.

In nearly every case the degree of aeration was determined in the first place with the gas unlighted. This enables one at the outset to pick out burners presenting a high resistance to the flow of gas and air, and provides a basis for estimating the relative importance of thermal and injector effects in determining the final aeration of the burner.

The tests have all been conducted with gases of a specific gravity not far removed from 0·5, and as a matter of convenience a works supply was used having a specific gravity ranging from 0·477 to 0·500. The gas for any particular series of tests was stored in a 200 c.ft. experimental holder, and drawn upon as required. The complete series of tests with any one burner usually extended over several days, and it was found impossible to keep the specific gravity of the gas constant for the whole series, even when working upon gas from one filling of the holder. There was a progressive lowering of the specific gravity of the gas when standing in the holder, which was indicated quite plainly by the differential column apparatus, and was consistent with the removal of CO_2 from the gas as shown by analysis of the portions used in tests on successive days. For gas of sp. gr. 0·5 a removal of 1 p.ct. of CO_2 would reduce the sp. gr. by 0·010—*i.e.*, by 2 p.ct.

The analyses given in Table 1 indicate the general character of the gases used, and where the specific gravity calculated from the analysis differs from that quoted in connection with any particular series of tests, the difference may be ascribed to the changes taking place in the holder between the times of making the aeration tests and gas analyses respectively. It was in this connection that the development of a rapid and reasonably accurate method of determining specific gravity was of the greatest service (see Part II).

The gases were all produced by steaming in vertical retorts, a certain amount of water gas also being added, and it will be noted that the nitrogen content is low, 10 to 11 p.ct. The average amount of air theoretically necessary for the complete combustion of 1 c.ft. of the gases used was 3·89 c.ft. and there was very little variation in the different samples. Due allowance was made for the small amount of oxygen already present in calculating this air requirement, which is the amount actually to be supplied either as primary or secondary air.

The air-gas ratios were determined in the manner already described for other burners—*i.e.*, samples were drawn from the burner at a point where mixing of gas and air might be assumed to be reasonably complete, and the CO_2 produced per c.ft. of the mixture when burned

TABLE 1.—*Particulars of Gases used for Aeration Tests with Lighting Burners.*

Gas.	F.	G.	H.	I.	J.	K.	M.	Average.
Analysis:								
CO_2	3·6	3 5	4·0	3·9	3·4	3·5	4·1	3·7
C_mH_n	1·9	2·0	2·2	2·1	1·8	2·1	2·4	2·1
O_2	0·6	0·7	0·9	0·6	0·8	0·6	0·6	0·7
CO	15·0	13·8	13 8	14·2	14·3	15·7	16·3	14·7
H_2	46·6	46·5	46·4	47·1	47·6	47·6	46·2	46·9
CH_4	21·1	22 6	22·2	21·9	21·9	21·0	20·7	21·6
N_2	11·2	10·9	10·5	10 2	10·2	9·5	9·7	10·3
	100·0	100·0	100 0	100·0	100·0	100·0	100·0	100·0
Sp. gr. of dry gas from analysis. Dry air = 1·00	·490	·487	·491	485	·477	·482	·500	·487
Calc. calorific value, B Th.U. gross, per c.ft.	457	470	471	468	463	466	469	466
C.ft. air required per c ft. of gas for complete combustion	3·81	3·94	3·93	3·92	3·87	3·89	3·89	3·89

over copper oxide was determined. This was compared with the CO_2 produced upon combustion in the same way of the gas in use. A small correction for CO_2 present in the air of the room was applied. All analyses were made in duplicate.

Lighting burners are comparatively small appliances and extremely sensitive to changes in the degree of aeration. Special care was therefore necessary to see that the sampling device and method of sampling, while securing a representative sample of the mixture, interfered as little as possible with the normal action of the burner. This necessitated a very small sampling tube, and the samples were drawn into a mercury sampler of 120 c.c. capacity through a steel tube of only 1 mm. external diameter (½ mm. bore), and from 4 to 6 min. were required for collecting a sample. Provision was made for maintaining a slow stream of the mixture to be sampled through a branch arm by a regulated "pull" from a water pump; but even had this not been done, the dead-space in the connecting tube (only 15 in. long) would have had little effect upon the aeration value. The steel tube was silver-soldered into a small brass bush which could be screwed into an appropriate place in each burner. The sampling points are indicated by arrows in figs. 1 to 9. In all cases the lighted burner was allowed to run for at least an hour before commencing aeration tests, and for about half-an-hour after any readjustment of gas rate, so that fair equilibrium should be attained in the thermal condition of the burner.

The tests with the various burners are not reported in the order in which they were made, and it will be noted that in a number of cases subsidiary experiments have been conducted to elucidate points of interest. As in previous reports, observed gas rates are given which have not been reduced to the usual standard temperature and pressure. In the case of unlighted burners, the gas and air would be at the same temperatures within 1° or 2° Fahr., and volumetric air-gas ratios would be unaltered on reduction to standard conditions. In the case of lighted burners it will be seen that the gas rate for a given pressure is often appreciably affected by heating-up of the nipple by conduction or radiation. There is great uncertainty as to the temperature of the air injected when it reaches the air ports with the lighted burners. Ordinary thermometers cannot be used for determination of its temperature, because any attempt to screen them from the effects of radiation would inevitably prevent the free access of air to the air ports of the burner. In the later types of inverted burners the incoming air is considerably heated. From the method of determination, the air-gas ratios calculated are the equivalent ratios on the basis of gas and air at the same temperature, whatever the actual temperature of either may have been during the test.

The tests were conducted at pressures within a few hundredths of an inch, ½ in., 1 in., 2 in., and 4 in. w.g. for each series. On figs. 1, 4, and 7 two pipes are shown. The one nearer the burner is that to which the pressure gauge is attached, the pressure being determined with the burner in operation. The other is for the gas supply. The aeration results were carefully plotted for each pressure, and the values given in the tables were read off from the original curves to correspond exactly with the pressure quoted. Facilities were not available for combining accurate photometric determinations with the aeration measurements. In most cases where changes in illuminating power are reported, they were of such a character as to be unmistakable, while in others use was made of approximate determinations with the Lumeter.

UPRIGHT INCANDESCENT BURNER (No. 1).

The upright burner chosen for test was a recent pattern by a well-known maker (fig. 1). It was extremely simple in construction, and the body could hardly be made shorter than in this model (overall length of burner and nipple 3⅞ in.). The principal resistance in the burner was undoubtedly the head of pierced refractory material, in which the total area for passage of gas was about two-thirds that of the minimum cross-section of the mixing tube. The burner was very similar to the simple burner designated "No. 1" in the 1st and 2nd Reports of the Gas Investigation Committee, or that described as "No. 3" in the Uddingston tests of the 2nd Report. It differed from both, however, in so far that a variable needle-regulated nipple replaced the fixed nipples of the earlier burners. The air ports consisted of slots in two concentric movable cylinders. The maximum air-port area with 8 slots fully open was ·50 sq. in., which was 3·4 times the throat area of the mixing tube. The sampling tube in this burner was screwed into the side-wall of the expansion immediately below the burner head, where it could not obstruct the free travel of the air-gas mixture.

TABLE 2.—*Upright Incandescent Burner (No. 1).*

Gas Used.—Gas J, Table 1.
Calorific Value.—463 B.Th.U. gross per c.ft.
Total Air Requirement.—3·87 c.ft. per c.ft. of gas.
Nipple.—Variable nipple, No. 10.

I.—Burner fitted with mantle and chimney; *gas unlighted;* air ports fully open. Average meter temperature during tests, 62·5° Fahr. Barometer, 30·3 in. Sp. gr. of dry gas, 0·484 (dry air = 1·00). See fig. 12, curve A.

Gas Pressure. Inches Water Gauge.	Uncorrected Gas Rate. C.Ft. per Hour.	Air-Gas Ratio.	Air-Gas Ratio as Percentage of	
			Value at 4 in. Pressure.	Total Air Requirement.
0 50	2·30	3·47	79	90
1·00	3·23	3 87	88	100
2 00	4·45	4·14	94	107
2 50	4·94	4 23	96	109
3 00	5 40	4 30	98	111
4 00	6 25	4 41	100	114

II.—Burner fitted with mantle and chimney; *gas lighted;* air ports fully open. Average meter temperature during tests, 62° Fahr. Barometer, 30·0 in. Sp. gr. of dry gas, 0·478. See fig. 12, curve B.

0 50	2·30	2·04	80	53 (1)
1 00	3 22	2·24	87	58 (2)
2 00	4 47	2 45	96	63 (3)
2 50	4 92	2 50	98	64
3 00	5 34	2 54	99	65
4 00	6 15	2·56	100	66 (4)

III.—Burner fitted with mantle, *chimney removed; gas lighted;* air ports fully open. Average meter temperature during tests, 63·5° Fahr. Barometer, 30·0 in. Sp. gr. of dry gas, 0·478. See fig. 12, points marked "x."

1 00	3·14	2 16	84	56
4 00	6·11	2·58	100	67 (5)

(1) Only ¼ in. of mantle giving useful illumination.
(2) About ⅜ in. " " " "
(3) About half the mantle passably well heated. Much better general effect by closing all but one air slot.
(4) Mantle fully heated and burner slightly noisy. Slightly better result with only two air holes open.
(5) As with chimney, but partial closing of air holes renders results slightly inferior.

Minimum cross-section of mixing tube = 0·150 sq. in.

Fig. 1.—For aeration curves see Fig. 12.

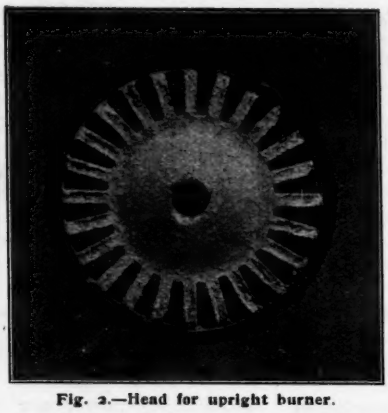


Fig. 2.—Head for upright burner.

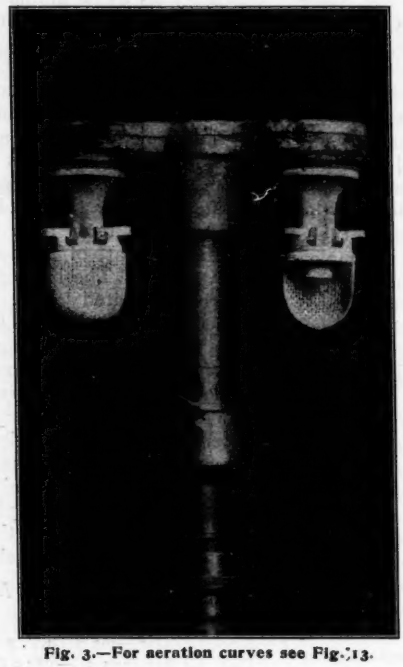


Fig. 3.—For aeration curves see Fig. 13.

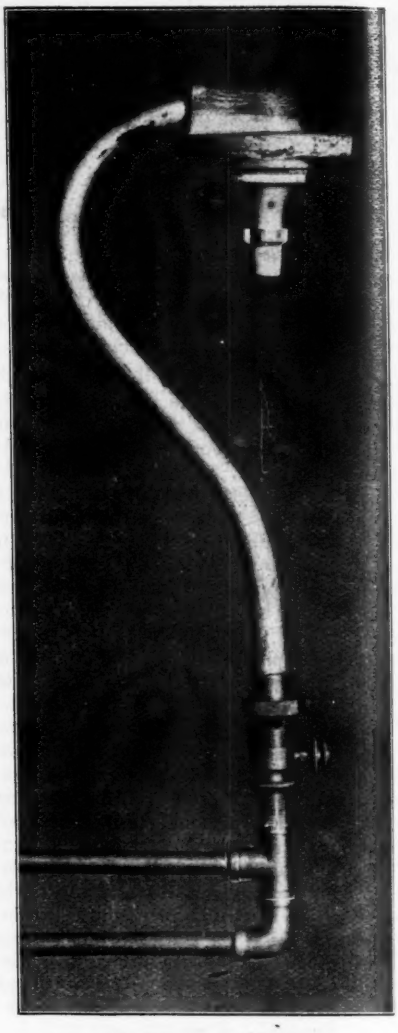


Fig. 4.—For aeration curve see Fig. 15.

The aeration curves for this burner were of a type which has become quite familiar, showing a rapid increase in aeration with pressure up to about 2 in. w.g., after which the further increase in aeration with pressure was relatively small (fig. 12). The degree of aeration reached with the unlighted burner was the highest attained in the experiments recorded in this report—viz., 4·41 c.ft. of air per c.ft. of gas, thus exceeding the amount of air theoretically necessary for complete combustion of the gas by 14 p.ct. Had the gas been one of 500 or 525 B.Th.U. gross per c.ft., however, and of the same specific gravity, exactly the same air-gas ratio would have been attained, but this same amount would then have represented a quantity somewhat short of that theoretically necessary for complete combustion. The aeration curve obtained for the lighted burner when fitted with the usual cylindrical glass chimney (6 in. high) was practically of the same shape throughout as for the unlighted burner, but the aeration had fallen to only 58 p.ct. of its former value; the highest air-gas ratio recorded being 2·56 c.ft. of air per c.ft. of gas at 4 in. w.g. pressure. Under these conditions, when burning gas of the quality indicated, at a rate of slightly over 6 c.ft. per hour, the mantle (usual "C" size) was fairly uniformly heated throughout, and the burner was just on the point of making the purring noise usually associated with full or over-aeration. While this degree of aeration may rightly be regarded as "over-aeration" for the purposes of combustion of this particular grade of gas in such a burner, it represents only two-thirds of the amount of air necessary for the combustion of the gas, and the remainder must be supplied as secondary air. As a matter of fact, the noise was eliminated and the illuminating power of the burner was appreciably increased by closing all but two of the eight air slots at this pressure, thereby reducing the primary aeration. (N.B.—This is by no means a reduction of the primary air to 25 p.ct. of its former value. See later). It would seem from observation of this burner that gas of the quality in question, when supplied with some 60 p.ct. of its theoretical air requirement as primary air, burns with a flame which is rather too conical to yield the best results with the usual type of cylindro-conical upright mantle, and it is necessary, especially at the lower gas rates, to enlarge the flame

Fig. 5.—Front view showing both mantles.

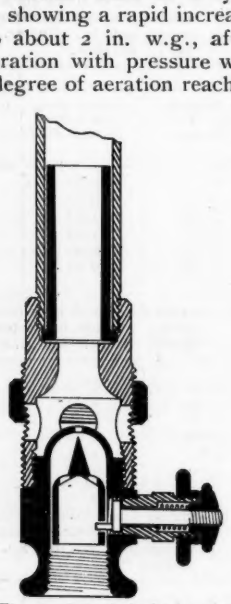


Fig. 6.—Detail of nipple, about full size.

by cutting down the primary air. A larger area of the mantle will then be heated, but the vigour of the combustion will be reduced. It is not possible to say, without resort to experiment, what part must be played by intensity, and what by illuminated area of mantle to secure the most efficient result in any particular case. It is certain, however, that regulation of the primary air gives us a means of controlling flame size and shape in the case of the upright mantle burner, and that so long as it is desired to obtain the maximum efficiency from the existing type of mantle and burner, this must be done by restricting the primary air to a quantity considerably short of that theoretically necessary for complete combustion of the gas. In these experiments, the highest degree of aeration, although considerably short of theoretically complete aeration, has definitely not yielded the highest efficiency and illuminating power. The third group of experiments in Table 2 was made with the chimney removed. (Points marked "x," fig. 12). In the 2nd Report of the Gas Investigation Committee, pages 291-293, it was pointed out that many upright burners were used in this state, and that the illuminating power was in consequence frequently lower than it might otherwise be. The beneficial effect of the chimney must be due almost entirely to the control which it exercises upon the secondary air supply and to conservation of heat in the neighbourhood of the mantle, for the above experiments indicated a practically negligible difference in the primary aeration figures whether the chimney was present or absent. The greatest difference was at 1 in. pressure, and this was due in part to the reduced gas rate consequent upon heating-up of the gas nipple because of a reduction in the cooling stream of air which the chimney develops around the burner body.

STREET LIGHTING BURNER (No. 2).

The burner chosen for test was one in extensive use for street lighting by the Manchester Corporation Gas Department, and was kindly supplied by the Superintendent of Street Lighting (fig. 3). It was provided with a single fixed orifice for gas delivery, the gas nipple being mounted above a small floating-plate governor which cut down the pressure at the nipple to about 2½ in. w.g. As it was desirable, for the purposes of our experiments, to test up to 4 in. pressure, the governor was removed. The stem of the burner was a plain parallel tube 5¼ in. long by ½ in. bore, provided with two five-sixteenth in. diameter holes for air intakes. The maximum air-port area was thus 0·78 times the cross-section of the mixing tube. The burner was fitted with a cast-iron superheater head carrying two Sugg fireclay nozzles for No. 2 (medium) mantles. In carrying out some of the tests with the unlighted burner, a sheet of tin 12 in. in diameter was mounted on the stem of the burner three-quarters of an inch above the air intakes, to prevent contamination of the air supply with gas discharged from the nozzles. With the lighted burner this precaution was unnecessary, as the draught generated by the burner carried the products of combustion away from the air ports.

The aeration-pressure curve for the unlighted burner was very similar to that for the upright burner, although the air-gas ratios are all much smaller (about three-quarters of the value for the upright burner), and the change in direction of the curve below 1 in. pressure was rather more pronounced.

TABLE 3.—*Inverted Street Lighting Burner (No. 2).*

Gas Used.—Gas F, Table 1.
Calorific Value.—457 B.Th.U. gross per c.ft.
Total Air Requirement.—3·81 c.ft. per c.ft. of gas.
Nipple.—Fixed orifice No. 14. Governor removed.

I.—Burner without mantles; *gas unlighted;* air ports fully open. Average meter temperature during tests, 62° Fahr. Barometer, 29·9 in. Sp. gr. of dry gas, 0·494 (dry air = 1·00). See fig. 13, curve A.

Gas Pressure. Inches Water Gauge.	Uncorrected Gas Rate. C.Ft. per Hour.	Air-Gas Ratio.	Air-Gas Ratio as Percentage of	
			Value at 4 in. Pressure.	Total Air Requirement.
0·25	1 60	2 16	67	57
0·50	2·31	2·76	86	72
1 00	3·37	2·90	90	76
2·00	4·82	3·06	95	80
2·50	5·39	3 11	97	81
3 00	5 93	3·14	93	82
4·00	6 82	3·22	100	84

II.—Burner fitted with 2 medium mantles; *gas lighted;* air ports fully open. Average meter temperature during tests, 62° Fahr. Barometer, 30·2 in. Sp. gr. of dry gas, 0·490. See fig. 13, curve B.

0·50	2·19	1·48	61	39
1·00	3·16	1 60	88	42
2 00	4·57	1 68	92	44
2·50	5·17	1·74	96	46
3·00	5·68	1 78	98	47
4·00	6·57	1·82	100	48

Some additional tests were made to ascertain, if possible, the cause of these small air-gas ratios. Tests were made at 4 in. pressure (gas unlighted) with and without the mantles on the nozzles. The air-gas ratios did not differ by more than 1 p.ct. from one another or from those already obtained. The closely fitting mantles therefore were not the cause.

There was in the upper part of each nozzle a wire-gauze grid, about ⅝ in. dia. The area occupied by wires (20 per lineal inch, 28 S.W.G.) was approximately equal to that of the spaces between them—i.e., 0·152 sq. in. —which was nevertheless still twice that of the final outlet area at the tip of each nozzle—viz., 0·0767 sq. in. Comparative tests were made at 4 in. pressure with and without these gauzes in position. The air-gas ratio without the gauze was definitely the higher, but only to the extent of 2 to 3 p.ct. This, it should be pointed out, was for a new gauze. In practice these mixing and dis-

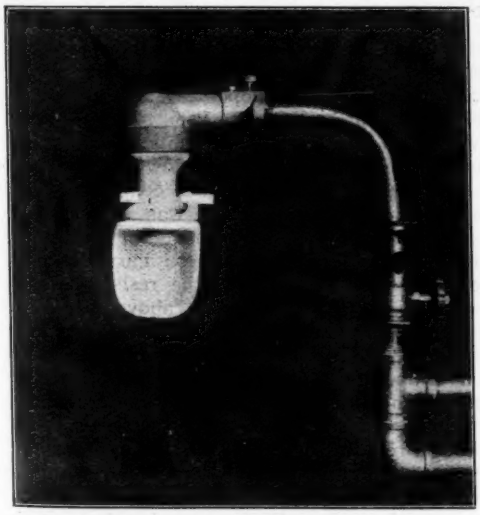


Fig. 7.—Gallery removed to show superheater and nozzle.

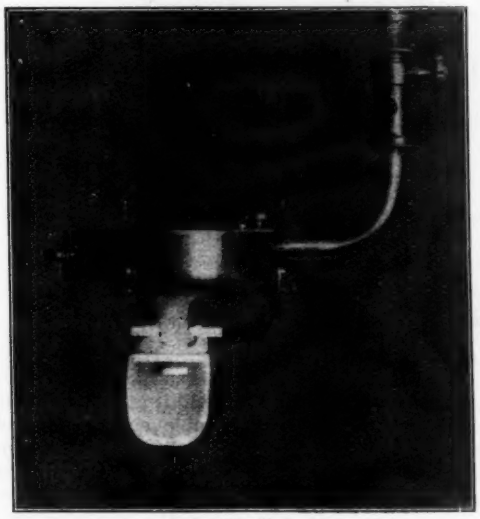


Fig. 8.

For aeration curves see Fig. 16.

tributing gauzes act as filters, and, particularly in domestic use, become corroded and covered with partially carbonized dust of a fluffy character, which may seriously restrict the area for the flow of the air-gas mixture, and consequently reduce the degree of aeration.

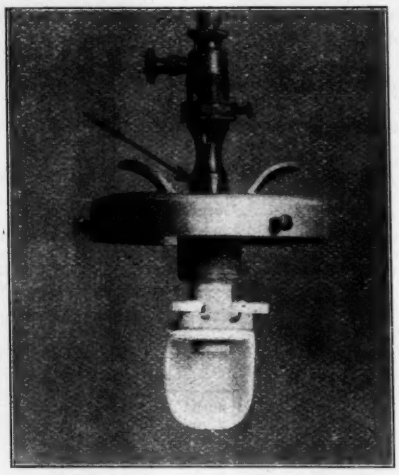


Fig. 9.—For aeration curves see Fig. 117.

The question naturally arose as to whether the air ports were of adequate size or not. The most convincing answer would have been given by repeating the tests with enlarged air ports. This was not practicable; but comparative tests were made at 1 in. and 4 in. pressure with the air ports fully open, and again, when only half open. The results indicated a reduction of the air-gas ratio to 83·5 p.ct. of the fully open value at 4 in. pressure, and to 79 p.ct. at 1 in. pressure. The mean reduction in aeration on half-closing the air ports of this burner was thus only about 20 p.ct., and it is reasonable to assume, therefore, that any practicable enlargement of the openings beyond their present "fully open" dimensions would have relatively little effect upon the air-gas ratio. In passing, it is of interest to note that the reduction in aeration was not a strictly constant proportion over the range of gas pressures used, and that a reduction of the air-port area to one-half affected the degree of aeration in a more marked manner than halving the effective area at the base of the nozzles by the insertion of wire gauze.

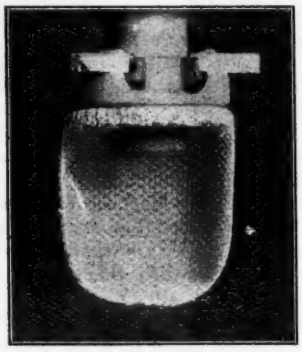


Fig. 10.

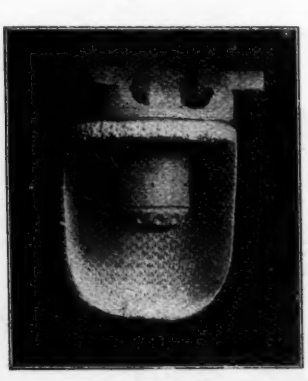


Fig. 11.

Enlarged views of alternative nozzles for above burner.

The tests with the lighted burner yielded an aeration curve of the same general type, with, however, a much lower degree of aeration. It approximated to 56 p.ct. of the corresponding values for the unlighted burner, and at its very best (4 in. pressure) was only 1·82 c.ft. of air per c.ft. of gas, or 48 p.ct. of the theoretical air requirement for this grade of gas. At 1 in. pressure, about one-third of the mantle was heated, while at 2 in. seven-eighths of the mantle was heated, and illumination might be considered just satisfactory. From 2 in. upwards, Lumeter measurements showed the illuminating power to be increasing approximately in proportion to the increased gas delivery. At the highest pressure the mantle was fully illuminated; there was no evidence of wastage of gas above the mantle; and the burner was just short of making a noise. Even if the burner had been capable of injecting a greater quantity of air, it is highly probable that the air shutter would have been closed to reduce the degree of aeration to about the above value, which seemed to represent almost ideal working conditions for the burner, mantle, and gas in use. (See also burner No. 3). It is clear, therefore, that the satisfactory operation of the burner was very dependent upon a secondary air supply. The reduction in the gas rate at a given pressure with the lighted burner was due to heating-up of the gas nipple by conduction and radiation. The superheater head was estimated to have a temperature not far removed from 200° C. at the highest gas rate.

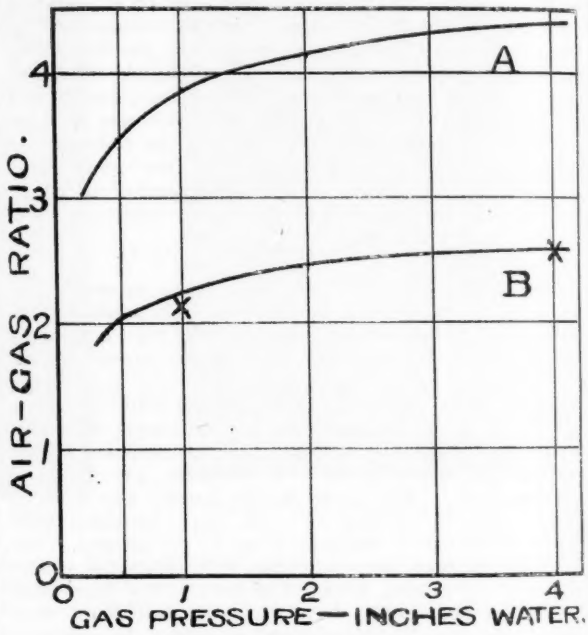


Fig. 12.—Burner of Fig. 1.

At 2½ in. pressure, the mantles being removed, the flames from the nozzles shot downwards to a length of 2½ in., with well-marked inner cones half-an-inch long. The observed air-gas ratio was 1·96, and is marked "x" on fig. 13. The increase in aeration above the corresponding pressure-point on curve B must not be ascribed to the removal of the resistance presented by the mesh of the mantle (see above), but rather to a reduction in the superheater and nozzle temperatures, the heat generated being less favourably placed for raising their temperatures than when generated in the confined space bounded by the mantles. It is noteworthy that at no time was any flame visible below the mantles, although removal of them would show long flames from the nozzles, and puncturing the mantles with holes of any size (say ⅛ in. dia. and upwards) always allowed flames to come through. Surface combustion on the mantle fabric with the aid of secondary air is probably, therefore, an important factor in determining the illuminating

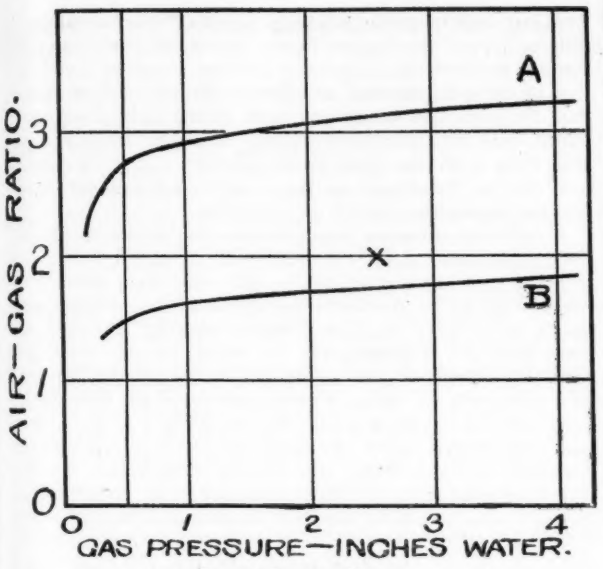


Fig. 13.—Burner of Fig. 3.

power. In this connection a careful exploration was conducted of the region around one of the mantles when the burner was operating at 4 in. pressure. Samples were drawn from the points indicated on fig. 14, and were at once analyzed for CO_2 in the large Haldane air-analysis apparatus. The dotted line, approximately $\frac{1}{4}$ in. away from the mantle, runs through points representing CO_2-concentration of 0·5 p.ct. As the undiluted products of combustion would contain about 12 p.ct. of CO_2, there must be an ample excess of air along the line thus mapped out. The method of sampling would not permit of closer approach to the surface of the mantle than $\frac{1}{4}$ in.; but it is plain that secondary aeration can play an important part in the operation of lighting burners, and that a considerable proportion of the necessary air can be effectively applied in this manner.

STREET LIGHTING BURNER (No. 3).

Burner No. 3 was a street lighting burner of a different type, but also fitted with a superheater head (figs. 4 and 5). It differed from the Manchester burner

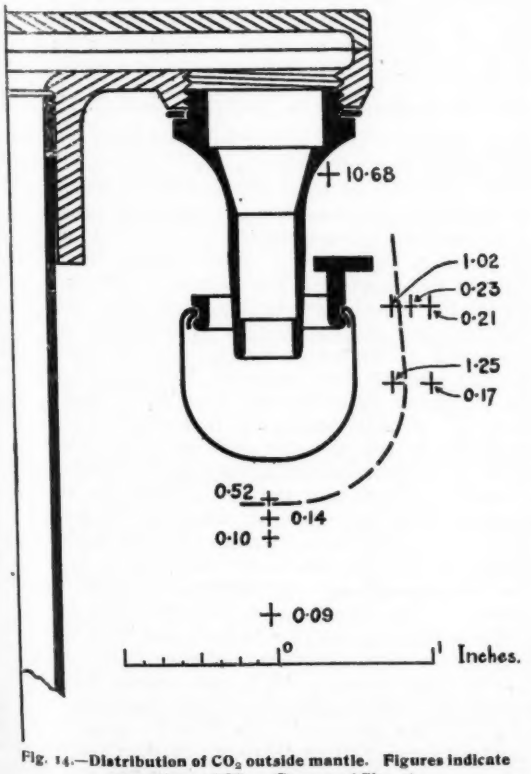


Fig. 14.—Distribution of CO_2 outside mantle. Figures indicate percentage of CO_2. (Burner of Fig. 3).

in being fitted with a variable nipple, and the long swan-neck bend of small bore ($\frac{3}{8}$ in.) connecting the nipple with the burner head might be expected to offer a considerable resistance. Immediately above the gas nipple the tube was still further contracted by a small funnel-shaped throat tube $1\frac{1}{4}$ in. long and only 9/32 in. dia. as shown in fig. 6. The two mantle nozzles were transferred from the Manchester burner to this one, so that the final outlet resistances should be identical for both burners.

The aeration curve for the unlighted burner was of the usual type, though not identical in shape with that of the previous burner. It will be observed that the gases used with burners Nos. 2 and 3 had about the same specific gravity, and that the gas rates at equal pressures were closely similar. The degree of aeration with burner No. 3 unlighted, however, was only about 90 p.ct. of that with burner No. 2.

The results obtained with the lighted burner (11.) presented a feature of interest, in so far that a maximum degree of aeration was attained between 2 and 3 in. pressure. This was not an unreasonable result, for with this burner unlighted, and with the other burners also, the air-gas ratio was increasing only slowly with pressure above $2\frac{1}{2}$ in. w.g. At the same time it was known that the heating-up of the burner caused a marked diminution in the air-gas ratio—with quantities so delicately balanced it was quite possible for the adverse thermal effect to exceed the injector effect and yield a reduced air-gas ratio upon increasing the pressure, and consequently the thermal delivery. An attempt was made to reproduce this phenomenon; but it was not exhibited by curve C, fig. 15, which conforms with the others.

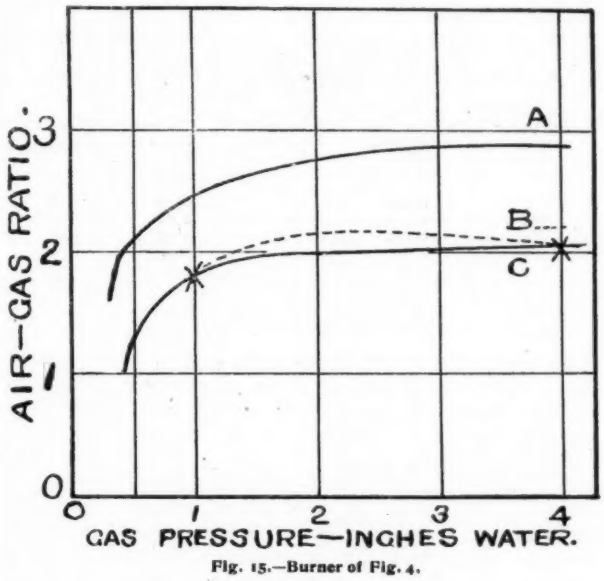


Fig. 15.—Burner of Fig. 4.

It was found that upon lighting-up from the cold this burner always went through the same cycle of changes. At first the burner was silent, and the velocity of the more highly aerated mixture of the cold burner was sufficient to maintain a stable flame. After some three minutes the nozzles and superheater warmed up, the air-gas ratio fell, the rate of flame propagation increased, probably to a greater extent than the rate of mixture flow (due to thermal expansion in the superheater and nozzles), and the burner became noisy and unstable.

Shortly after this, the illumination of the mantles would fall-off appreciably. The illumination could be restored by temporarily closing the air ports, afterwards opening them fully again, when good illumination would be obtained almost indefinitely unless some trifling hiatus in the action of the injector caused a resumption of the inferior illumination conditions, which then became permanent. Eventually it was discovered that when the illumination fell-off in this way the burner was operating in a partially "struck back" condition, the gas burning just inside the nozzle (or possibly as far back as the gauze), which became extremely hot. The effect of a

TABLE 4.—*Inverted Street Lighting Burner (No. 3).*

Gas Used.—Gas G of Table 1 for I. and II.; Gas I for III.; Gas J for IV.
Calorific Values.—470, 468, and 463 B.Th.U gross per c.ft. respectively.
Total Air Requirement.—3·94, 3·92, and 3·87 c.ft. per c.ft. of gas.
Nipple.—Variable nipple, No. 13.

I.—Burner with two mantles, *gas unlighted;* air ports fully open. Average meter temperature during tests, 61° Fahr. Barometer, 29·0 in. Sp. gr. of dry gas, 0·497 (dry air = 1·00). See fig. 15, curve A.

Gas Pressure. Inches Water Gauge.	Uncorrected Gas Rate. C.Ft. per Hour.	Air-Gas Ratio.	Air-Gas Ratio as Percentage of	
			Value at 4 in. Pressure.	Total Air Requirement.
0·50	2·35	2·11	73	54
1·00	3·42	2·47	86	63
2·00	4·83	2·76	96	70
2·50	5·37	2·82	98	71
3·00	5·89	2·85	99	72
4·00	6·75	2·88	100	73

II.—*Gas lighted,* air ports fully open. Average meter temperature during test, 62·5° Fahr. Barometer, 28·9 in. Sp. gr. of dry gas = 0·492. See fig. 15, curve B, dotted.

0·50	2·28	1·30	64	33
1·00	3·27	1·80	89	46
2·00	4·66	2·12	105	54
2·50	5·19	2·14	106	54
3·00	5·68	2·14	106	54
4·00	6·51	2·03	100	52

III.—*Gas lighted,* air ports fully open. Average temperature during test, 61·5° Fahr. Barometer, 28·9 in. Sp. gr. of dry gas, 0·484. See fig. 15, curve C.

0·50	2·28	1·30	63	33
1·00	3·28	1·77	87	45
2·00	4·69	1·99	97	51
2·50	5·21	2·01	97	51
3·00	5·70	2·02	98	52
4·00	6·53	2·06	100	53

IV.—*Gas lighted,* air ports varied. Average temperature during tests, 65° Fahr. Barometer, 30·3 in. Sp. gr. of gas, 0·487. Gas pressure, 2·5 in. w.g. Gas rate, 5·07 c.ft. per hour (uncorrected).

Number of Turns of Regulating Ring.	Area of Opening Exposed. Sq. In.	Area as Percentage of Maximum Opening.	Air-Gas Ratio.	Air-Gas Ratio as Percentage of Maximum.
0	0·150	100	2·07	100
3	0·075	50	2·02	98
4	0·048	32	1·97	95
6	0·000	0	*Nil*	0

Cross-section of mixing tube at throat ($\frac{3}{8}$ in. dia.) = 0·0621 sq. in.
Air port area, 4 holes $\frac{7}{32}$ in. dia. = 0·150 sq. in. total.
Overall length of burner and nipple, 10·5 in.

temporary closing of the air ports was to supply a mixture with a lower rate of flame propagation, while still maintaining a considerable rate of mixture travel. This brought the flame outside the nozzle, which cooled somewhat, and stable conditions were obtained—very delicately balanced, it is true—with the flame outside the nozzle. The point is one of considerable practical importance in burner adjustment, particularly when critical adjustment for maximum efficiency is being attempted. Thus, it is possible to allow a burner to become hot, and then adjust it on the photometer bench to maximum efficiency, apparently in a perfectly stable condition. If now the burner is extinguished and allowed to cool, it may not be possible for it automatically to resume its former illuminating power when lighted, owing to the necessity for passing through an intermediate condition on warming-up, which would give rise to the partially "struck-back" condition referred to above. At 4 in. pressure we have been able to obtain two air-gas ratios with this burner, a higher one corresponding with the flame outside the nozzle and lying above curve B (fig. 15), only obtainable by adjustment of the hot burner, and the other represented by curve B, corresponding with a partially "struck-back" condition. On the whole, curve C lies slightly below curve B; but this is in part due to the lower specific gravity of the gas used for the tests of curve C.

Burners Nos. 2 and 3 were used at about the same gas rates with the same mantles and nozzles. From comparison of fig. 13, curve B, with fig. 15, curve C, at say 3 in. pressure, it would seem that the difference between 1·8 and 2·0 c.ft. of air per c.ft. of gas, for gas of the quality used, represents the margin between safe working and unstable working due to "over-aeration," although even the higher figure represents only one-half the air theoretically necessary for the complete combustion of the gas, injected as primary air. It will be noted that the reduction in air-gas ratio of the lighted as compared with the unlighted burner is rather smaller with this than with the Manchester burner. This is doubtless due to differences in the design of the superheater and the disposition of the mixing tube.

A brief examination was made as to the effects of air-port adjustment upon the behaviour of this burner. It is plain that the air shutter is only one of a number of resistances to be overcome in working the burner, and much will therefore depend upon whether, in its fully open position, it constitutes the main, or any considerable proportion of the whole resistance of the burner. The air ports of this burner consisted of four holes 7/32 in. dia., with a total area of 0·150 sq. in. They could be closed by a threaded cut-off ring taking six complete turns to close the air ports entirely. As the ring was obscuring circular openings, the reduction in air-port area per turn was not uniform. The results of tests with three air-port adjustments are indicated in Table 4 (iv). The first result for the fully open air ports shows an air-gas ratio in good agreement with curves B and C already obtained. The burner was slightly noisy. Upon reducing the air-port opening by half (i.e., 3 turns of ring) the illuminating power was increased, and the air-gas ratio fell, but only by a trifling amount—2 p.ct. This may be contrasted with the 20 p.ct. change brought about by half-closing the air shutter of the Manchester burner. A further turn of the ring reduced the air-port area to one-third of its original amount, but the air-gas ratio had only fallen by 5 p.ct. in all, and the illuminating power of the burner was excellent. It is clear that for 6 turns—i.e., complete shut-off—the air-gas ratio would be nil. Practically the whole of the effective regulation of aeration, therefore, fell upon the last two turns of the ring; and if the original maximum air-gas ratio was low, it could clearly not be ascribed to insufficient air-port area in this case.

Further, these figures and those obtained with other burners show very plainly that the degree of aeration is *not* proportional to the area of air-shutter opening provided. Other workers also have shown that the relation between air-port area and degree of aeration for given conditions of operation must be determined for individual burners, and that the degree of aeration is not proportional to air-port area. Nevertheless, the contrary erroneous view, that aeration is proportional to air-port area, is still sometimes encountered.

UNIVERSAL REVERSIBLE INVERTED BURNER (No. 4).

This series of tests was conducted with a domestic burner designed to take the popular "universal" inverted mantle. The burner used is illustrated in figs. 7 and 8. The nipple points upwards, injecting into a tube of 13/32 in. bore, bent at right-angles, delivering into an aluminium alloy casting, which in its turn carries the refractory nozzle for the support of the mantle. Such burners are intended for attachment to brackets, etc., which previously carried upright fittings. The burner could also be reversed as shown in fig. 8. Illuminating power tests had already been made at Uddingston with this type of burner (2nd Report, Gas Investigation Committee, pp. 280-284, burners 5, 6, and 7), but the main reasons for its selection for aeration tests were that on account of its position the injector would keep relatively cool during operation of the burner, and the air supply was drawn from a region not likely to be mixed with products of combustion. In these respects it is in strong contrast to the type of burner next to be tested (see burner No. 5), although the latter is possibly the more common. The nipple used with the upright burner No. 1 was attached to this burner, and was worked at practically the same gas rates and pressures. As 6 c.ft. per hour may seem a high gas consumption for a universal inverted mantle, even with due allowance for the C.V. of the gas used (466 B.Th.U. gross), it may at once be noted that at this consumption there was no visible wastage of gas above or about the mantle, and

the gas rate might with advantage have been still further increased.

TABLE 5.—*Reversible Inverted Burner* (*No.* 4).

Gas Used.—Gas K, Table 1.
Calorific Value.—465 B.Th.U. gross per c.ft.
Total Air Requirement.—3·98 c.ft. per c.ft. of gas.
Nipple.—Variable nipple No. 10, injecting upwards.

I.—*Gas unlighted;* air ports fully open. Average meter temperature during tests, 62° Fahr. Barometer, 29·6 in. Sp. gr. of dry gas = 0·480 (dry air = 1·00). See fig. 16, curve A.

Gas Pressure. Inches Water Gauge.	Uncorrected Gas Rate. C.Ft. per Hour.	Air-Gas Ratio.	Air-Gas Ratio as Percentage of	
			Value at 4 in. Pressure.	Total Air Requirement.
0·50	2·34	2·31	77	59
1·00	3·15	2·68	89	69
2·00	4·52	2·86	95	73
2·50	5·05	2·89	96	74
3·00	5·53	2·93	98	75
4·00	6·37	3·00	100	77

II.—*Gas lighted;* tests unmarked made with air ports fully open; those marked "*" made with air ports closed to 75 p.ct. of original area. Average meter temperature during tests, 60·5° Fahr. Barometer, 29·7 in. Sp. gr. of dry gas, 0·476. See fig. 16, curve B.

0·50	2·33	1·33	Not comparable with rest of column	34
1·00	3·13	1·70		44
2·00	4·37	1·99		51
*2·00	4·37	1·90	95	49
*2·50	4·85	1·96	98	50
*3·00	5·30	1·98	99	51
*4·00	6·06	2·01	100	52

Exit of mantle nozzle $\frac{3}{8}$-in. diameter—*i.e.*, 0·110 sq. in.
Diameter of globe gallery, $3\frac{3}{8}$ in.

The aeration-pressure curve for the unlighted burner calls for little comment. It does, however, illustrate the difficulty of talking of the injecting power of a nipple or jet as a separate property. Comparing Tables 2 and 5, for example, we have the same nipple delivering gas under almost identical conditions as regards specific gravity and pressure, but into different burners. In the case of the upright burner, the air-gas ratio was 4·4 at 4 in. pressure, while for the inverted burner it was only 3·0, this proportion being retained approximately over the whole pressure range.

Owing to difficulties with back-firing, it was not possible to complete the comparative tests with the lighted burner and fully open air ports over the whole pressure range up to 4 in. w.g. The air ports consisted of two holes $\frac{3}{8}$ in. dia. (total area, 0·220 sq. in.), and, for the pressures above 2 in. w.g., the available air port area was reduced to 0·165 sq. in.—*i.e.*, 75 p.ct. of its original value. From previous experience it was assumed that this would not reduce the aeration by more than 5 to 10 p.ct., but it permitted the gas to be burned effectively in the burner, and the aeration line with the ports fully open (had the gas permitted it) would probably have been not far removed from the dotted line B on fig. 16.

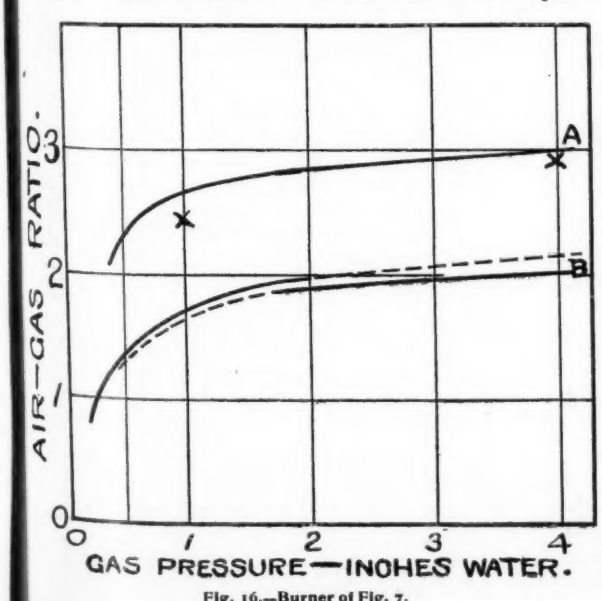


Fig. 16.—Burner of Fig. 7.

In other respects the curves presented no unusual features. Once again, however, it was found necessary, in order to secure satisfactory combustion of the gas, to cut down the primary air supply below that which the burner was capable of injecting, and considerably (50 p.ct.) below that theoretically necessary for the complete combustion of the gas.

It was hoped to test this burner with the injector working in the inverted position as shown in fig. 8. From examination of the burner some little doubt existed as to whether the regulating pin would retain its exact location in the nipple when thus inverted, and the tests should preferably be carried out in the two positions with a burner injecting by means of a fixed orifice. For what they are worth, however, the results of two tests are indicated by "x" on fig. 16 for the unlighted burner injecting downwards. They are both clearly below curve A—a result which would be consistent with the extra load thrown upon the injector in working against the up-cast effect of the relatively light mixture which fills the tube between the mantle nozzle and the nipple. That the nipple becomes appreciably heated with this burner will be seen from examination of the relative gas rates at equal pressures for the lighted and unlighted burners.

INVERTED BURNER (No. 5).

This burner was of a type which probably represents by far the greater number of inverted gas burners in use to-day. The nipple was a variable one injecting downwards into a relatively short mixing tube, and a universal mantle was used.

The burner was a high-class article, and the injector was constructed of relatively few parts, all machined from the solid and carefully assembled. The general dimensions can be judged from fig. 9, the external diameter of the globe gallery being $3\frac{1}{4}$ in.

With this burner, alternative nozzles were used. The first was of the usual type with an outlet $\frac{3}{8}$ in. diameter. It will be seen from fig. 10 that this nozzle projected only a short distance into the mantle. The second nozzle was of the more recent pepper-box type, perforated with 31 holes, each approximately 1/16 in. dia. The total outlet area was thus slightly less for the pepper-box nozzle than for the plain nozzle. It will be seen from comparison of figs. 10 and 11 that the pepper-box nozzle projected considerably further into the mantle than the plain.

The investigation of such a burner presented new difficulties, both in making the experiments and in interpreting the results. The injector, on account of its position, became very hot, as was shown by the difference in gas rate for equal pressures with the lighted and unlighted burner. Most manufacturers provide such burners with deflector plates, either of metal or of refractory material, immediately below the air-intakes. For practical and for æsthetic reasons such deflectors must be kept small; and it is doubtful whether they do more than protect the injector from flame with consequent firing of gas at the nipple, or from a very hot and concentrated stream of products of combustion. It is certain that a burner of this type draws its primary air supply from a region containing products of combustion. In considering injector efficiency, therefore, it may be necessary to credit the injector in the first place with all the mixture which it causes to circulate through the burner, irrespective of its composition. Of the quantity circulated, however, only part can be regarded as "fresh air" carrying with it the usual proportion of oxygen for combustion of the gas, and may be rightly regarded as the "air-gas ratio" of the burner for purposes of combustion.

These two quantities can be differentiated by determining, in the mixture samples, first the free CO_2 (partly derived from that already present in the unburned gas, and partly from admixed products of combustion) and secondly, the CO_2 produced on completing the combustion of the mixture over copper oxide. The calculations are indicated in Appendix II.

The first tests were made at 1 in. and 4 in. w.g. with the plain nozzle and the air shutter fully open, the gas

TABLE 6.—*Universal Inverted Burner (No. 5).*

Gas Used.—Gas M, Table 1.
Calorific Value.—469 B.Th.U. gross per c.ft.
Total Air Requirement.—3·89 c.ft. per c.ft. gas.
Nipple.—Variable nipple No. 15.

I.—Plain nozzle, no mantle, *gas unlighted*, air ports fully open. Average meter temperature during test, 60·6° Fahr. Barometer, 29·5 in. Sp. gr. of dry gas, 0·501 (dry air = 1·00). See fig. 17, points marked "x."

Gas Pressure. Inches Water Gauge.	Uncorrected Gas Rate. C.Ft. per Hour.	Air-Gas Ratio.	Air-Gas Ratio as Percentage of		Volume of Products of Combustion Injected per C.Ft. of Gas.
			Value at 4 in. Pressure.	Total Air Requirement.	
1·00	3·54	3·72	98	96	..
4·00	7·46	3 81	100	98	..
II.—As above, but with air shutter open only two turns of ring. Average meter temperature during test, 63·0° Fahr. See fig. 17, curve A.					
0·50	2·49	1·80	75	46	..
1·00	3·65	2·26	94	58	..
2·00	5·24	2·35	98	60	..
2·50	5·90	2·37	99	61	..
3·00	6·48	2·38	99	61	..
4·00	7·56	2·40	100	62	..
III.—As II., but with universal mantle fitted and *gas lighted*. Average meter temperature during test, 64·6° Fahr. Barometer, 29·5 in. Sp. gr. of dry gas, 0·500. See fig. 17, curve B.					
0·50	2·27	0·90	45	23	0·010
1·00	3·25	1·66	82	43	0·024
2·00	4·58	1·95	96	50	0·067
2·50	5·10	1·96	98	50	0·071
3·00	5·57	1·98	99	51	0·075
4·00	6·41	2 02	100	52	0·084
4·00 with Vitreosil globe)	6·41	2·05	..	53	0·047
IV.—Pepper-box nozzle, no mantle, *gas unlighted*, air ports fully open. Average meter temperature during tests, 62·9° Fahr. Barometer, 29·4 in. Sp. gr. of dry gas, 0·499.					
1·00	3·61	3·68	96	95	..
4·00	7·51	3·83	100	98	..
V.—As IV., but with air shutter open only two turns of ring. Average meter temperature during test, 62·6° Fahr. Barometer, 29·4 in.					
1·00	3·64	2·22	93	57	..
4·00	7·56	2 38	100	61	..
VI.—As IV., but with universal mantle fitted, *gas lighted*. Average meter temperature during test, 65·0° Fahr. Barometer, 29·4 in. See fig. 17, curve C.					
1·00	3·17	1·79	72	45	0·045
2·00	4·49	2·27	92	58	0·057
2·50	5·06	2·32	94	60	..
3·00	5·56	2·39	97	61	..
4·00	6 41	2 47	100	63	0·057
4·00*	..	2·08	..	54	0·036

* Air ports open only two turns of regulating ring.

Throat area of mixing tube (¼ in. dia.) = 0·049 sq. in.
Maximum air port area, 4 holes ½ in. dia. = 0·196 sq. in.
Air port open two turns of regulating ring = 0·040 sq. in. = 82 p.ct. of throat area, or 20 p.ct. of maximum opening.
Outlet area plain nozzle = ⅜ in. dia. = 0·110 sq. in.
" " pepper-box nozzle (31 holes, $\frac{1}{16}$ in. dia.) = 0·095 sq. in.
Distance from tip of nozzle to mantle-ring support: Plain nozzle, $\frac{11}{16}$ in. Pepper-box nozzle, $\frac{15}{16}$ in. (1⅛ in.).

being unlighted. The results are indicated by "x" on fig. 17, and show a relatively high air-gas ratio, 3·7 to 3·8. The burner, however, would not operate with this degree of aeration, every attempt to light it being accompanied by a vigorous back-fire. The air shutter was therefore closed until the gas would burn with slightly noisy flames, which would ordinarily be described as "well aerated." The burner was allowed to cool down and the tests with the unlighted gas were repeated with the air openings thus restricted. The air-gas ratio was reduced to about 62 p.ct. of the value obtained with the fully open air shutter, although the air-port area was reduced to 20 p.ct. of its former value.

The burner was then tested with the gas lighted; the results being indicated by Table 6 (iii) or Curve B, fig. 17. The first point to observe is that, although the nipple was untouched between tests (ii) (gas unlighted) and tests (iii) (gas lighted), the heating-up of the burner in the latter tests was sufficient to reduce the gas rate by an amount ranging from 9 p.ct. at ½ in. pressure to 15 p.ct. at 4 in. pressure, the drop being progressive with increasing thermal development at the mantle. This type of burner, with the gas nipple immediately above the nozzle, exhibits the phenomenon to a more marked degree than any of the others. The temperature of the gas passing through the nipple might be roughly estimated from this drop in gas rate as about 100° C. Curves A and B, fig. 17, are of the same type, although the aeration falls away more rapidly and the shoulder on Curve B is less marked below 2 in. pressure, due to the modifying influence of thermal effects. The amount of air taken in as primary air with the burner in its normal working state was, as in previous examples, only about one-half the total theoretical air requirement of the gas. The air-gas ratios given are for air of normal composition. In the last column of Table 6 the amount of products of combustion taken in with the primary air has been calculated, and should be added to the air-gas ratio values to determine the total volume of mixture injected. From the analysis of the gas "M," Table 1, the products of combustion would have the following composition by volume, and the figures in Table 6, for the volume of products of combustion injected, assume the water formed during combustion to remain as steam.

CO_2. . . 10·4 p.ct.	H_2O (as steam)" 20 6 p.ct.	N_2 . 69·0 p.ct.

The amount of products of combustion drawn into a burner would be proportional to the quantity of air drawn in (*i.e.*, the air-gas ratio) and to the concentration of the products of combustion around the air-intakes of the burner. It will be observed that the amount of products of combustion injected in our tests ranged from 1 p.ct. of the gas volume at ½ in. w.g. to 8·4 p.ct. of the gas volume at 4 in. pressure, and this would have the same effects, so far as combustion is concerned, over the usual working range of the burner, as the addition of 7 to 8 p.ct. of inerts to the gas. As a matter of fact, it is possible to estimate the concentration of the products of combustion in the primary air supply, by dividing the volume of products taken in per c.ft. of gas by the sum of this quantity and the air-gas ratio. When considered in this way, and having regard to the proximity of the injector to the burning gas, the amount of admixture of products of combustion with the primary air supply is surprisingly small, amounting in these tests to only 2 to 3 p.ct. by volume of the air supply over the range 2 to 3 in. pressure. Actually, the figures show that the concentration of products of combustion in the primary air supply increases rather more rapidly than the rate at which gas is burned; but the quantities involved are so small that our determinations do not

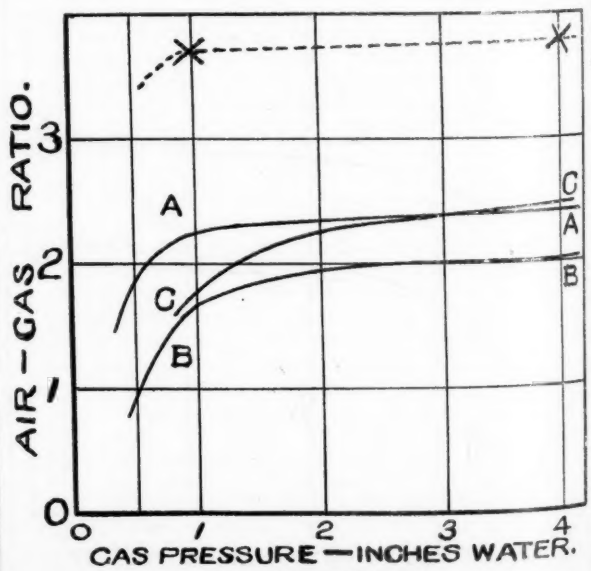


Fig. 17.—Burner of Fig. 9.

permit of more than a qualitative statement in this respect.

At 2 in. pressure when using the plain nozzle the burner was silent, and three-quarters of the mantle was heated. At 4 in. pressure the burner was slightly noisy and the mantle was fully heated, with a small amount of flame showing above the mantle ring. This could not be eliminated by increasing the primary air supply, any attempt to do so resulting in back-firing. A test was made at 4 in. pressure after fitting to the burner one of the usual open types of Vitreosil globes, the air and gas adjustments remaining unaltered. The burner became slightly more noisy and would back-fire more readily. The air-gas ratio was very little affected, but rather less products of combustion were taken-in with the primary air, probably because of the more effective air circulation around the burner when fitted with the globe.

The first tests with the air shutter fully open and the gas unlighted, using the pepper-box nozzle, gave air-gas ratios almost indistinguishable from those with the plain nozzle, so that the perforated end did not offer any appreciably greater resistance to the flow of gas and air than the plain nozzle. Slightly lower air-gas ratios were obtained with the pepper-box nozzle, when the air opening was throttled to correspond with the conditions of tests for the plain nozzle (gas unlighted). The difference, however, was very small, and there were slight changes in sp. gr. of gas, in atmospheric conditions, and in the re-setting of the air shutter, which would easily account for the observed changes in air-gas ratio.

The pepper-box nozzle would permit the air shutter to be opened fully, and back-firing did not occur, although the air-gas ratios obtained were some 20 p.ct. higher than could be used with the plain nozzle at corresponding gas rates and pressures. At 3 and 4 in., however, the burner was slightly noisy, and it was clear that with an air-gas ratio of about 2·4 :1 the practical limit of primary aeration was approached for the burner and gas in use. Actually, there was very little change in illuminating power at 4 in. pressure when the air shutter was closed to correspond with the conditions of test for the plain nozzle; and the best illuminating power at the gas rate corresponding with 4 in. pressure would probably be obtained with a primary air-gas ratio lying somewhere between 2·08 and 2·47 for the pepper-box nozzle, when supplied with gas of the quality indicated. While the burner with the plain nozzle could not be started up from cold without back-firing to give a final air-gas ratio of 2·05 at 4 in. pressure with the hot burner, the pepper-box nozzle would permit of starting up from cold with the air shutter fully open, there being no tendency to back-fire at any stage as the burner approached its final working temperature.

DISCHARGE OF GAS THROUGH LIGHTING BURNER NIPPLES.

The work detailed in this section of the report was carried out as a preliminary to the aeration tests already described, and was intended, originally, to furnish some guide to the selection of nipples for those tests.

The discharge of gas through orifices of 0·25 in. dia. and upwards has been studied by many workers, and for ordinary gas-works pressures the relationship between discharge and pressure is fairly well established.

For the behaviour of very small orifices such as are used in multiple-orifice lighting-burner nipples, the work of Dr. J. S. G. Thomas may be consulted (Phil. Mag., Vol. XLVI, Nov., 1923), bearing in mind that the orifices used in his work were orifices in thin plates, and were prepared with extreme care.

The American Bureau of Standards has indicated some peculiarities in the behaviour of orifices of the sizes commonly used in domestic gas cookers, especially those due to differences in the shape of the nipple on the approach side of the orifice, and the thickness of wall through which the hole is made.

The single-orifice lighting-burner nipple is usually of a size intermediate between those studied by Dr. Thomas and by the Bureau, and it was considered desirable to establish the relation between discharge and pressure for such orifices, for town gas. It must be remembered that in commercial gas nipples the orifices rarely comply with the description of "holes in thin plates;" the thickness of wall usually being comparable with the diameter of the hole, and the shape of the nipple on the approach side of the orifice shows great differences, and is apparently a matter of taste with different manufacturers. Moreover, it was desirable to ascertain the characteristics of variable orifices fitted with regulating needles, such as were to be used in our aeration tests.

For this purpose a number of lighting-burner nipples were obtained of the type represented by Fig. 6. They were taken to pieces and subjected to examination with a hand lens, only those specimens which appeared satisfactory being retained. In most cases it was necessary to take off with an oilstone the burr left by drilling the orifice; to remove machine cuttings from the nipple; and to scrape off the burr left by drilling the holes in the regulating needle. Nothing was done to modify the size or shape of any parts, however, and these operations may be regarded merely as very careful finishing and assembly of the nipples. Careful cleaning, followed by examination and measurement of the orifice with a low-power microscope, preceded assembly.

In most of the nipples the clearance between the regulating needle and the body was large, bearing in mind the necessity for the accurate centring of the tip of the needle in a small orifice; and for fine regulation a more positive connection between the needle and the regulating spindle would seem desirable.

With each of fourteen selected nipples three series of tests were made at a number of selected gas pressures from 0 to 4·5 in. water gauge (w.g.).

(*i.*) With the regulating needle removed, so as to determine the behaviour of the simple orifice.
(*ii.*) With the needle in position, but drawn as far back as the mechanism of the nipple would allow, in order to obtain the maximum discharge.
(*iii.*) With the needle set so as to give a gas rate appropriate for the burner to which the nipple would be fitted.

The process of testing was simple, and it was mainly a question of careful observation of gas rates and corresponding pressures, and the application of a number of corrections in order to obtain gas rates of the requisite degree of precision for further calculation. Each nipple was mounted in turn above a fine-regulating quadrant-cock on the outlet of a $\frac{1}{10}$ c.ft. experimental meter; the gas pressure being measured immediately behind the nipple on a U-gauge filled with xylol. The gas was drawn from a 200 c.ft. holder, and its density was determined as indicated in Part II. of this report. By careful regulation of room temperature and the selection of suitable days for testing, it was possible to obtain atmospheric conditions not far removed from 60° Fahr. and 30 in. barometer, whereby large corrections to standard conditions could be avoided. A constant pressure of 5 in. w.g. was maintained at inlet meter, although the pressure at the nipple ranged from 1 to 4·5 in. It is not quite clear whether the volume and density of the gas should be considered with regard to the conditions prevailing on the pressure side of the orifice, or on the outlet side, although the difference in the two methods only exceeds the error of our experiments when the pressure exceeds 3 in. w.g. Actually all volumes and densities have been reduced to the prevailing atmospheric conditions (*i.e.*, zero w.g.) at outlet nipple.

The time required for a suitable number of whole revolutions of the meter was observed for each gas pressure, from which the gas rate was calculated. This was corrected for pressure at inlet meter (back to atmospheric), calibration error of meter, and variation in capacity of the meter per revolution, according to its rate of revolution (overdriving error), but *not* to 60° Fahr. and 30 in. bar., by means of the usual "tabular numbers." The barometric pressure and the temperature of the gas being known, it was possible to calculate the specific gravity of the moist gas under the prevailing conditions at the nipple, dry air at 60° Fahr. and 30 in. barometer being taken as standard (1·00).

The densities of the gases used in these tests rarely differed by more than 2 p.ct. from 0·475 (dry air = 1·00), and it was therefore a convenience to calculate, from the observed gas rate (corrected to the extent indicated above) and the density of the gas under the conditions at the nipple outlet, the corresponding discharge of gas of sp.gr.

0·475 (dry air at 60° Fahr. and 30 in. barometer = 1·00), assuming, for the purpose of calculating the correction, that the gas rate would be proportional to the square root of the density. The corrections to the observed gas rate to obtain the corresponding rates with gas of sp.gr. 0·475 were only small. Determinations were made at 1, 2, 3, and 4 in. water gauge (w.g.).

There was some difficulty in expressing concisely the results of the investigations. Graphical representation of the relationship between discharge and gas pressure was used; but there was room for considerable difference of opinion as to the position of the curve which best fitted the observations, and the method was abandoned as not sufficiently exact. Attempts were made to fit various curves to the observed points on the assumption that the discharge was proportional to the square root of the pressure, in turn making the curve fit at the highest pressure (4 to 4·5 in.), at 2·5 in. pressure (as being a typical working pressure), or at some other pressure which gave the best agreement between the square root curve and the observed points. It was evident that in the majority of cases it was not possible to fit any square-root curve to the observations without involving an error of more than 1 or 2 p.ct. of the gas rate, over some part or other of the pressure range 0-4·5 in. w.g. Numerous attempts to express the difference between observed and calculated discharges as a simple correction term to be applied to the square-root curve did not lead to any generally useful formula applicable to the whole of the nipples examined.

It was believed that the observations might be represented more accurately by an exponential formula of the type $q = Ap^B$, where q is the gas rate and p the pressure. A and B being constants, and the value of B not far removed from 0·5 (when $q = A\sqrt{p}$, or $Ap^{0.5}$). Logarithms were therefore taken of the pressures and corresponding gas rates, and by the usual mathematical methods the best-fitting straight line was calculated to pass through the points representing the observations with each nipple; and from the slope of this line the value of B was determined.

A formula of the above type, with the insertion of the appropriate values for the constants, gave a more accurate representation of the results over the whole pressure range than any of the square-root formulæ, although the relation found may be purely empirical. Even with this formula, however, the difference between observed and calculated values for discharge frequently exceeded 1 p.ct. over certain ranges; and the deviations were such as to suggest that the formula did not represent the best curve through the observed points (by method of derivation it was the best *simple exponential* curve), and that a more complex formula would be required. The matter was, however, not followed further.

In the Tables which follow, particulars are given as to the nipples used and the results obtained.

Dimensions of Orifices in Gas Nipples Tested.

Nos. 1—6.—Intended for burners with No. 2 (medium) mantles.
,, 7—11.—Intended for burners with universal mantles.
,, 12—15.—Miscellaneous nipples.

No. of Nipple.	Mean Diameter of Orifice. Inches.	Mean Thickness of Wall at Orifice. Inches.	Thickness. / Diameter.
1	0·0357	0·025	0·70
2	0·0350	0·021	0·60
3	0·0350	0·034	0·97
4	0·0358	0·028	0·78
5	0·0351	0·020	0·57
6	0·0355	0·032	0·90
7	0·0601	0·034	0·57
8	0·0581	0·036	0·63
9	0·0593	0·028	0·47
10	0·0597	0·031	0·53
11	0·0598	0·034	0·57
12	0·0435	0·024	0·55
13			
14	0·0476	..	..
15			

Nos. 1—6 and 7—11 are nominally all of one size.

In looking over the indices for the discharges from plain circular orifices (*i.e.*, nipples with needles removed), it will be observed that they range from 0·45 to 0·53. One would hesitate, however, to ascribe these variations to experimental error and take an average of the whole series, for it is evident that the low values for Nos. 6 and 7 could be repeated, as could the high value for No. 13. These indices are therefore characteristic of the nipples in question. Careful examination, however, failed to disclose any mechanical differences in the nipples which would satisfactorily account for the observed changes in the indices, and even greater variations may very well be expected in practice, when one remembers the care with which the above nipples were selected and prepared. There are in the table, however, comparatively few examples of indices greater than 0·5.

From columns 5 and 7 it would appear that the index is very little altered by insertion of the regulating needle into the orifice, although the figures in column 7 show, if anything, rather less variation than those in column 3, with a general average slightly below 0·5—say, 0·48.

The conclusions to be drawn from the figures below are that the relation between discharge and gas pressure for

Discharge of Gas through above Nipples.

Determined for gas of sp. gr. 0·475 at moment of discharge. (Dry air at 60° Fahr. and 30·0 in. barometer, = 1·00).
The table gives the values of A and B in the expression $q = Ap^B$.
Where q = gas rate in c.ft. per hour.
p = pressure behind nipple in. w.g.

No. of Nipple.	No Regulating Needle Inserted.		Maximum Opening with Needle Inserted.		Needle Adjusted to give Working Gas Rate.	
	A.	B.	A.	B.	A.	B.
1.	2.	3.	4.	5.	6.	7.
1	1·779	0·472	1·726	0·472	1·381	0·473
2	1·594	0·490	1·335	0·470	1·335	0·470
3	1·774	0·515	1·764	0·491	1·363	0·473
	1·787	0·489				
	1·798	0·490				
4	1·811	0·490	1·828	0·468	1·365	0·470
	1·857	0·474				
	1·860	0·475				
5	1·768	0·490	1·788	0·494	1·369	0·494
					1·116	0·514
					1·226	0·503
6	1·712	0·466	1·730	0·454	1·390	0·450
	1·765	0·452			1·339	0·452
	1·750	0·460				
	1·767	0·455				
7	4·794	0·452	4·499	0·461	3·182	0·468
	4·792	0·458			3·257	0·470
	4·804	0·453				
8	4·663	0·479	3·961	0·487	3·220	0·487
9	4·984	0·477	4·277	0·483	3·159	0·483
10	4·811	0·466	4·320	0·480	3·156	0·486
11	4·635	0·467	4·417	0·472	3·188	0·471
12	2·813	0·468	2·710	0·473	2·097	0·478
13	4·263	0·528	4·170	0·526	3·173	0·496
	4·252	0·530			3·190	0·491
					3·193	0·496
14	3·519	0·506	..	..	..	..
	3·504	0·509	..	..	..	..

nipples of the above type may be represented approximately by a formula of the type $q = Ap^B$, but that the index B as well as the coefficient A will be different with different nipples, and will usually be slightly below 0·5. This must be taken into account in precise work, and will involve a determination of the characteristics of the particular nipple in which we may be interested, especially if aeration is in question.

On the other hand, for general work, and for calculating changes in gas rate and thermal delivery to be expected for changes in pressure of (say) 1 in. w.g. above and below a working pressure for which a discharge has actually been measured, the usual assumption that the discharge is proportional to the square root of the pressure will probably suffice.

The following table shows the percentage error involved in assuming that the discharge is proportional to the square root of the pressure, if it should actually follow some other index. The table is arranged for all indices to give the same result at 2·5 in. pressure.

These discharge tests were made as preliminaries to aeration tests with lighting burners. There is no reason whatever for associating a high degree of aeration with a high index in the above formulæ, or expecting any relation between the two.

It was fully realized that the equations given only represented the relation between discharge and gas pressure. It might very well happen that a nipple would discharge its

Pressure and Gas Discharge.

Percentage correction to discharge rate calculated on basis of square root of pressure, if the true index of the exponential formula $q = Ap^n$ is that given at the head of each column. Agreement is made exact at 2·5 ins. w.g. for all indices, and the heavy line encloses all values for which the error is less than 1 p.ct.

p.	0·45	0·46.	0·47.	0·48.	0·49.	0·50.	0·51.	0·52.
0·5	+8·4	+6·7	+5·0	+3·3	+1·6	*Nil*	−1·6	−3·2
1·0	+4·7	+3·7	+2·8	+1·9	+0·9	*Nil*	−0·9	−1·8
1·5	+2·5	+2·0	+1·5	+1·0	+0·5	*Nil*	−0·5	−1·0
2·0	+1·1	+0·9	+0·7	+0·4	+0·2	*Nil*	−0·2	−0·4
2·5	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*
3·0	−0·9	−0·7	−0·5	−0·3	−0·2	*Nil*	+0·2	+0·3
3·5	−1·7	−1·3	−1·0	−0·6	−0·3	*Nil*	+0·3	+0·7
4·0	−2·3	−1·8	−1·4	−0·9	−0·4	*Nil*	+0·4	+0·9
4·5	−2·8	−2·3	−1·7	−1·1	−0·6	*Nil*	+0·6	+1·2
5·0	−3·4	−2·7	−2·1	−1·4	−0·7	*Nil*	+0·7	+1·4

gas in a rough and turbulent manner not favourable for highly efficient injection, or that the position of the gas stream as regards centring in the mixing tube or inclination to its axis might be at fault. There are independent sources of variation in the behaviour of injectors upon which discharge-pressure relations can furnish no information, and experimental determination of the degree of aeration is essential.

PART II.

SPECIFIC GRAVITY OF GASES.

In connection with the investigation of the aeration of burners, and the discharge of gases through orifices, it has been desirable to know with some accuracy the specific gravity of the gas being used. An error not greater than ± 0·5 p.ct. was aimed at, or for a typical town gas (say) ± 2 in the third decimal place of the density figure. This section of the report will be divided into three parts, as follows:

1. A description of the instruments used for the determination of specific gravity.
2. Details of the methods used.
3. A comparison of a number of specific gravity determinations by different methods.

1.—Instruments for Determination of Specific Gravity of Gas by Differential Column Method.

The determination is made by measuring the difference in the pressure exerted by a column of gas and a similar column of air, from which data the specific gravity can be calculated as will be shown later. The method has been known for a number of years (*e.g.*, see Threlfall, Proc. Roy. Soc. A. 77, 1906), but was revived and a convenient arrangement of apparatus described by Blackie in 1922 ("An Apparatus for the Measurement of the Specific Gravity of Gases in Small Quantities," Alfred Blackie, M.A.; Fuel Research Board, Technical Paper No. 5). Preliminary tests had been made and the applicability of the method to the requirements of our research was under examination when the 11th Report of the Gas Investigation Committee was presented last year (see pp. 26 and 33, 11th Report, 1924). The description which follows is that of the apparatus and procedure which we have since developed and found to yield satisfactory results. In the main it follows the paper already referred to, but with amplification of the working details.

Gas and Air Columns.

The gas and air columns were contained in copper tubes of ⅛ in. bore, surrounded by a water-jacket built up of 1½ in. iron piping as shown in fig. 20. The tubes are each about 20 ft. long, this giving a pressure difference which can be measured with a degree of accuracy comparable with that of the other measurements involved. As it was not possible to find accommodation for an apparatus of this height inside the laboratory, it was secured to the outer face of the laboratory wall near a window, the window-ledge forming a convenient foundation for the pressure gauge. Each tube terminates in a cylindrical box 1½ in. dia. by 1½ in. deep, provided with a diaphragm perforated with a ⅛ in. hole, and a similar hole in the base. These boxes are used to minimize the effects of diffusion of air into the tubes while a test is in progress, and the bases of the two boxes should be at the same level with the outlet apertures close together. With this arrangement the sensitive pressure gauge sometimes showed oscillations which made it impossible to obtain reliable readings; this was probably due to mutual screening of one box by the other when the wind was in certain directions, and to eddies set up near the water jacket. The boxes were therefore enclosed in an outer chamber with a single perforation in its base, this being covered with a loosely fitting baffle plate. With this arrangement sufficiently steady readings have been obtained even in windy weather. A third copper tube was also fitted into the jacket to act as the bulb of an air-thermometer, as described by Blackie; but in addition a thermometer pocket of the usual type was provided where the water entered the base of the jacket. This was fitted with a mercury thermometer graduated

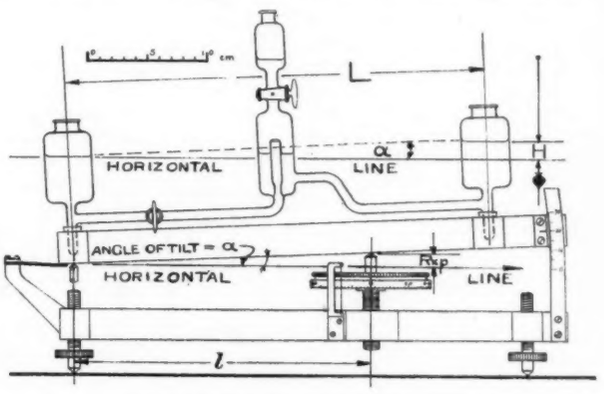


Fig. 18.—Outline diagram Chattock Gauge.

in tenths of a degree Centigrade. With a good flow of water through the apparatus there was very little difference between the temperature of the water entering the jacket and that overflowing from the top—the excess rarely being greater than 0·5° C. The greatest error thus introduced is under-estimation of the mean temperature of the tubes by 0·25° C. Perforated distance pieces were provided for the tubes about every 18 in., the perforations being ½ in. holes alternately at the centre and near the circumference of successive spacers.

Chattock Tilting Gauge.

The instrument used for measuring the pressure difference between the columns was a tilting manometer of the Chattock type made to our designs by Messrs. Scientific and Projections, Ltd., the novel features of which were described and illustrated in the 11th Report of the Gas Investigation Committee (p. 25). Fig. 18 shows the essentials of the instrument.

As the result of continued experience in the use of the gauge, further improvements have been effected. Control of the illumination of the instrument is very important if consistent readings are to be obtained. This is now effected by enclosing the gauge in a case to exclude most of the extraneous light. The source of illumination is an ordinary pocket flash lamp bulb perma-

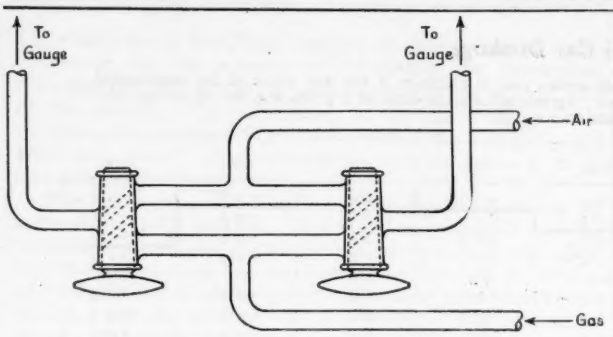


Fig. 19.—Change-over Cock System for Chattock Gauge.

nently fixed to the tilting member some 3 in. above the rear pivot, the light being directed as required by the mirror behind the centre vessel. Suitable wiring and a switch are provided. A black-paper collar encircles the upper part of the centre vessel and is adjusted by trial to cut off most of the light above the meniscus. The silhouette of the meniscus shows a very clearly defined line in the field of the microscope for setting, and, if the gauge is moved from place to place, trifling readjustment of the mirror is usually all that is required to reproduce the former conditions of illumination. The heating-up of the apparatus with such a source of light is negligible. The reading microscope is furnished with a Watson 1 in. parachromatic objective and a 6x eyepiece. This, with the usual microscope body-length, represents about as large a magnification as it is convenient to use, and only leaves about 1 mm. working distance between the objective and the walls of the centre vessel. A single silk fibre provides a suitable line in the eye-piece. Through the

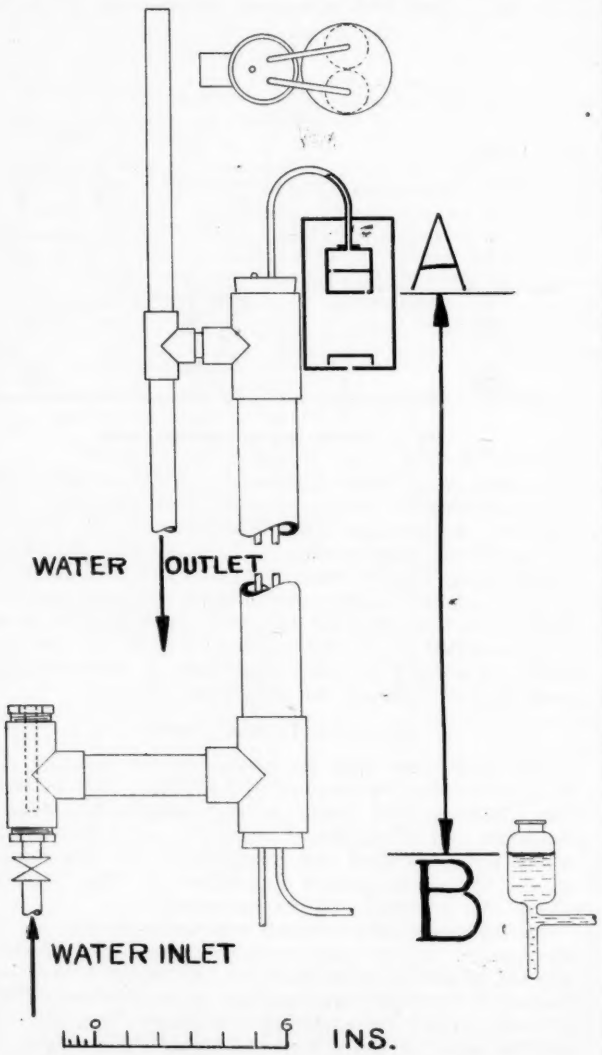


Fig. 20.—Water-Jacketed Gas and Air Tubes.

kindness of Dr. H. Hartley, our attention was called to a critical report upon a number of sensitive gauges used in the Aerodynamics Laboratory at the University of Toronto (School of Engineering Research University of Toronto, Bulletin No. 2, "Aerodynamic Papers," J. H. Parkin, 1921). As a result of this communication, it was decided to replace the castor-oil salt solution combination originally used in the gauge by one of "Nujol" and distilled water. "Nujol" is a proprietary brand of medicinal paraffin which we found to have a viscosity only about one-tenth that of castor oil; and it is immiscible with water. The density of the sample in use is 0·883 at 60° Fahr., changing with temperature at the rate of 0·00035 per °Fahr. The meniscus at the junction of the "Nujol" and water remains well-defined and free from scum over long periods, and accurate settings of the gauge are therefore facilitated. The use of a gauge liquid like distilled water, with well-known physical properties, also has much to commend it. Trouble was experienced at first owing to the solution of tap-grease by the "Nujol." The latter alone was, however, found to be a suitable lubricant for well-ground taps if these were not pressed too heavily into their seats, the taps turning with very little effort, and so causing the minimum disturbance of the gauge.

In our original gauge an attempt was made to secure sensitivity by making the innermost tube of small diameter—3 m.m. internal. The gauge responded quickly to small pressure changes, but the movement of the meniscus for a given tilt of the gauge was, contrary to expectations, small and irregular. This is to be associated with surface-tension phenomena. In the latest instrument, the bore of the inner tube has been increased to 9 m.m., and a meniscus height of 2 to 3 m.m. is used. Under these conditions, settings can be repeated easily to within ± 0·2 divisions of the micrometer head—*i.e.*, to ± 0·003 m.m. w.g.—and the time required for the gauge to take up its final reading is less than 15 seconds.*

At a convenient place in front of the gauge a wooden block has been secured to the bottom of the case. This carries two two-way cocks sealed together as indicated diagrammatically in fig. 19, connections being made permanently between these and the gauge by short flexible pieces of rubber tubing. It will be seen that this arrangement allows the gauge to be isolated; either limb can be supplied very expeditiously with gas or air at will, and both limbs can be subjected to the same pressure or to atmospheric pressure. Further, as connections are made from other apparatus to this cock system and not directly to the gauge, there is no risk of disturbing the adjustments of the latter while re-arranging connections, or by an accidental pull on the connecting tubes.

We have found that, when subjected to a rising temperature, the gauge exhibits a drift of zero which is by no means negligible. The amount of drift for a given change in temperature will depend upon the dimensions of the gauge, the nature and quantities of the liquids used for filling, and to some extent upon its initial temperature. A precise value cannot therefore be given. Experiments specially conducted for the purpose show, however, that for our manometer the drift is of the order of 2 micrometer divisions per °Fahr. change in temperature of the instrument. It is thus important that the temperature of the instrument should be kept constant during observations, or that the temperature should change slowly and steadily, so that an attached thermometer may indicate the temperature of the gauge with reasonable accuracy. A thermometer has been fitted to the gauge and surrounded by a water jacket which is made approximately of the same dimensions as the central vessel by the side of which it is mounted. It is not intended that the figure previously given for zero drift (2 divisions per ° Fahr.) should be used for the calculation of corrections. It is preferable that frequent zero checks should be made, together with temperature observations. The correction to intermediate readings can then be made in accordance with temperature readings made at corresponding times. It would be

* One revolution = 100 divisions on head = 1 m.m. lift on screw (approx.) = 1·4 m.m. w.g. difference in pressure.

Example of Determination of Specific Gravity of Town Gas.

—	Micrometer Reading.	Temperature. Gauge.	Temperature. Columns.
	9·078, 78, 74 — 0·001 Corr. for screw error, 0·000 zero drift = 9·077 Mean	49·1° Fahr.	..
1st Zero Reading	9·076 Corrected		
	11·864, 62, 62 — 0·000 Corr. for screw error, + 0·005 zero drift = 11·863 Mean	49·4° Fahr.	5·52° C.
1st Gas Reading	11·868 Corrected		
	11·855, 59, 58 — 0·000 Corr. for screw error, + 0·010 zero drift = 11·857 Mean	49·7° Fahr.	5·50° C.
2nd Gas Reading	11·867 Corrected		5·51° C.
	9·064, 60, 62 — 0·001 Corr. for screw error, + 0·015 zero drift = 9·062 Mean	50·0° Fahr.	
2nd Zero reading	9·076 Corrected	49·5° Fahr. Mean = 9·7° C.	5·51° C. Mean, −0·02° Corr. = 5·49° C.

Correction for Zero drift $= \frac{+\ 0\cdot015}{0\cdot9} = 0\cdot017$ per ° Fahr. Barometer, 29·74 in. at 64° Fahr. = 29·65 in. corrected.

11·868 1st gas reading	11·867 2nd gas reading
9·076 1st zero ,,	9·076 2nd zero ,,
2·792 Difference.	2·791 Difference.

2·7915 = Mean pull of gas column expressed in turns micrometer head.

2·7915 × 1·422 = 3·969 = Vertical displacement of water surfaces in m.m.

3·969 = Equivalent in m.m. w.g. at 4° C.

$$6221 \times 0\cdot001293 \times \frac{273}{278\cdot5} \times \frac{29\cdot65}{29\cdot92} = 73\cdot394 \times \frac{29\cdot65}{278\cdot5}$$

= 7·814 = Pressure due to air column under the same temp. and pressure conditions as in the gas colum (m.m. w.g.)

Then specific gravity of gas*

$$= 1 - \frac{3\cdot969}{7\cdot814} = 1 - 0\cdot5079$$

$$= 0\cdot4921.$$

* Wt. of 1 c.ft. of dry gas. / Wt. of 1 c.ft. of dry air. under the same conditions of temp. and press.

possible by suitable alteration of the relative sizes of the central and one of the outer vessels greatly to reduce this zero drift, but exact compensation could not be expected over a wide range of working temperatures. In addition to correction for zero drift, any considerable change in temperature will entail a correction for change in density of the water in the gauge. This may be obtained from tables (*e.g.*, Kaye and Laby's "Physical and Chemical Constants, 1918," p. 22), although the change may be neglected between 0° and 20° C., unless the pressure is required to a greater degree of accuracy than ± 0·2 p.ct.

The pressure exerted by a column of typical town gas of specific gravity 0·5 and length 20 ft. will be slightly under 4 m.m. w.g. For a determination of specific gravity to within ± 0·5 p.ct. it can be shown that this pressure must be known to within ± 0·02 m.m. w.g. Actually the pressure is obtained from the difference of two readings, each of which must therefore be known to within ± 0·01 m.m. w.g., *i.e.*, to within ± 0·7 divisions on the micrometer head. This, it should be emphasized, is the accuracy with which the absolute magnitude of the whole pressure reading should be known, and is distinct from the smallest *variation* in pressure which can be definitely measured on the gauge, previously given as ± 0·2 micrometer divisions. Very careful standardization and calibration of the gauge are therefore demanded in order to obtain pressure readings correct within the above limits. A description of the details of the calibration would be unduly lengthy, but it consisted essentially in mounting a mirror on the tilting member, and treating the system as an optical lever; the tilt for various micrometer settings being determined to about ± 1 second of arc, or ± 0·15 micrometer divisions. It may be mentioned that for several months the gas densities obtained by the use of this gauge were systematically higher by about 1 p.ct. than those obtained by other methods, this difference being about double the estimated experimental error. As a result of our calibration, the tilt of the gauge was found to correspond with a mean micrometer pitch of 1·0108 m.m., whereas we had previously assumed that the pitch of the screw was in accordance with our specification—viz., 1·00 m.m. Upon re-calculating the densities with the revised figure for the screw-pitch, the various methods gave results in good agreement with one another.

The gauge thus developed can hardly be regarded as portable in the ordinary sense of the word, but it may nevertheless find additional applications in the gas industry when it may be necessary to measure small pressure differences with precision. Among these may be mentioned pressures in burners, flue draughts exerted by gas appliances, ventilator suctions and pressures, Pitôt tube measurements, and the standardization of other types of sensitive gauges.

2.—Method of Making Specific Gravity Determination.

The water flow is established through the jacket surrounding the differential columns; the Chattock gauge is set up and adjusted by its longitudinal and cross levels; and the microscope set so that the image of the meniscus is approximately on the cross-wire. Between the gauge and the differential columns, two straight tubes about 10 in. long and $\frac{5}{8}$ in. dia., filled with calcium chloride, are placed horizontally and on a level with the surfaces of the water in the gauge. These serve to dry the gases entering the columns, and will remain effective for a considerable number of determinations. The control cock on the horizontal limb of the gauge is closed, and air is forced through the space in each end vessel and drying tube into the corresponding differential column. The air is conveniently supplied from an aspirator bottle; and about 2 litres through each tube, taking 3 to 5 minutes, is usually sufficient before determining the first zero reading of the gauge. The two taps permitting the air-flow are closed, and with one hand on the micrometer head the observer cautiously opens the control cock on the gauge, care being taken to keep the image of the meniscus near the line in the microscope eye-piece by manipulation of the micrometer head. The meniscus is then set as closely to the line as possible, and a reading on the micrometer head is taken. With the cock still fully open, the micrometer head is moved some 5 divisions, after which the meniscus is re-set to the cross line and the micrometer head is again read. A third setting and reading are made, and the temperature of the instrument is noted. The mean of the three readings constitutes the "first zero reading." The control cock on the gauge is next closed, and the gas which is to be exam-

ined is passed through one tube only, for 3 to 5 minutes. It will be found that the small copper tubes present a considerable resistance to the flow of the gas; and with an available pressure of about 5 in. w.g., gas will pass through the system at the approximate rate of only 1·7 c.ft. per hour, *i.e.*, about 2 to 3 litres of gas will be used. This is no disadvantage, however, as the drying of the gas by calcium chloride might not be satisfactory at greater speeds. During the last minute of this period, air should be passed through the other column. The gas and air are shut off, and three micrometer settings, together with a temperature reading of the instrument, are taken as in the case of air. The mean gives the "first gas reading." At the same time the temperature of the differential columns should be noted to 1/10°C., and the barometric height should be observed. If an approximate sp. gr. only is required, these two sets of readings will furnish the necessary data.

It is our practice, however, to close the control cock on the gauge and repeat the passage of gas for a further 3 minutes, and obtain a "second mean gas reading" from three settings in the same way. This is a safeguard against a faulty micrometer setting in the first test, or inadequate clearing of the gas tube from air. The control cock is closed, and both limbs are then swept with air for a further 3 minutes, thus restoring the apparatus to its original state; and from three settings a "second mean zero reading" is obtained, together with the corresponding temperature. Assuming that the meniscus has not been subjected to any violent displacement, the difference in the two zero readings indicates the extent of the zero drift. If, through faulty manipulation, the meniscus should be seriously disturbed, it is better to wait a few moments for the instrument to settle, and reject any difference figure obtained from values including the period of such disturbance. The calculation of the result is best illustrated by a worked example.

From the foregoing description the upper part of the table should be quite clear. The second correction—correction for screw error—is obtained from calibration data, and converts the micrometer reading into the equivalent reading on a perfect screw of the same effective mean pitch as that of the screw in use. The temperature corrections are obtained by comparison of the thermometers used with an N.P.L.–standardized thermometer. The barometric height should be accurate to 0·05 in. at least, so that the observed height must be reduced to standard conditions. The principal correction will be the temperature correction (for English barometers, mercury to 32° Fahr., brass scale to 62° Fahr.), usually involving a deduction of about 0·07 to 0·10 in. from the observed height. The factor 1·422, by which the mean micrometer difference is multiplied, is known as the "constant of the gauge." It is derived from careful determination of the dimensions indicated on fig. 18.

L = distance between the centres of the water surfaces in the outer vessels.
l = distance between line joining fixed pivots and axis of micrometer screw.
p = effective mean pitch of screw.
R_1 = first micrometer reading.
R_2 = second " "
$R = (R_2 - R_1)$ = turns of micrometer screw.
H = lift of water surface in right-hand vessel above that in left-hand vessel.
D = sp. gr. of liquid filling gauge (water at 4° C. = 1·00). The water and not the "Nujol" must be considered here.
α = tilt of gauge from horizontal.

Then pressure indicated by gauge
$= HD = LD \sin \alpha = LD \tan \alpha \cos \alpha$.
But if α is small, say less than 2°, we may write without significant error,
$= LD \tan \alpha = LD\ R_1 \frac{p}{l}$.
The pressure is obtained as a difference of two readings, thus—
$$P = L.D\,(R_2 - R_1)\,\frac{p}{l}.$$

$L.D\ \frac{p}{l}$ is a constant for any particular instrument, and is the "constant of the gauge." Had the temperature of the instrument been 15° C., for example, instead of 9·7° C., the density of the water would have been only 0·999, and consequently the value 3·969 would have been reduced to 3·965 in the second entry, to obtain the pull in m.m. of water of standard density. For 9·7° C. the correction is only 2 parts in 10,000, and is consequently negligible.

The next line in the table is a calculation of the pressure exerted by a column of air at the same temperature and pressure as the gas and of the same height. The height in question is that marked AB in fig. 20, and must be measured vertically and known to within a few millimetres. Where the apparatus is installed in a permanent position, it is convenient to measure once for all the height from the base of the diffusion boxes to the surface of the slab carrying the gauge. The distance from the slab to the mean height of the surfaces of liquid in the gauge is then deducted. This may differ slightly from time to time according to the filling and adjustment of the gauge, and is more easily checked than the whole height. In our apparatus as at present installed, the distance is 6221 m.m. (= 20 ft. 5 in. approx.).

0·001293 is the weight in grammes per c.c. of pure dry CO_2—free air at 0° C. and 760 m.m. pressure; 273 is the absolute temperature corresponding to 0° C., and 278·5, that corresponding to 5·5° C., the temperature of the columns; 29·65 is the corrected observed barometric height, and 29·92 the equivalent in inches of 760 m.m.

It is clear that for a particular installation a number of these factors will be constant, so that the arithmetical work in practice is much shorter than in this example. Thus, for our apparatus, the expression for the pressure due to the air column reduces to $73{\cdot}39\ \frac{B}{T}$ m.m. w.g. where B and T are the barometric height and absolute temperature of the gas column respectively.* If the weight of the water column indicated by the gauge is deducted from the calculated weight of the air column, the difference must be that of the gas column, since the apparatus is in equilibrium. The ratio of the weight of the gas column to that of the air column (or their equivalents in m.m. w.g.) gives the sp. gr. of the gas. A slight re-arrangement of the data gives an expression which can be calculated with less labour, viz. :—

$$\text{Sp. gr.} = \frac{\text{wt. of gas column.}}{\text{wt. of air column.}} = \left[1 - \frac{\text{wt. of water column.}}{\text{wt. of air column.}}\right]$$

The accuracy of the determination will be indicated later (section 3 below) when comparing the specific gravity values obtained by different methods for a number of gas samples.

It has been pointed out that the gauge reading may be doubled by modifying the procedure, and passing gas and air alternately through the right and left hand differential tubes. While this is true, it may require an inconveniently large tilt on the gauge, a correction for zero drift cannot be applied with the same certainty, and the gauge liquid is likely to become contaminated with gas to a serious extent if not swept with air from time to time. Sufficiently accurate readings can be obtained with 20 ft. tubes without adopting this plan.

3.—Comparison of Specific Gravity Determinations by Different Methods.

In the table which follows, a number of comparative specific gravity determinations are given covering a period of several months, these having been made in the course of other experiments. Samples of gas mixtures were taken simultaneously, and the determinations were made by alternative methods selected from the following :—

(i) *By the differential column method* already described.

(ii) *By gas analysis.* For this purpose the analysis was made as carefully as possible, each constituent was calculated to the second decimal place, corrected as indicated in Appendix I., and then rounded to the nearest 0·1 p.ct. C_mH_n was assumed to have a density 1·3 (air=1).

(iii) *By weighing* the carefully dried gas in sealed bulbs of about 290 c.c. capacity.

It was originally intended that this should form the standard with which the other methods might be com-

* $(6221 \times 0{\cdot}001293 \times \frac{273}{29\ 92} \times \frac{B}{T} = 73{\cdot}39\ \frac{B}{T}$ m.m. w.g.)

pared. The tests occupied much time and were executed with every care and precaution. Reviewing the whole of the conditions, however, and the limitations of the instruments available, it is doubtful whether we should be justified in ascribing to these figures a greater precision than ± 0·002, although it is possible that they are correct to ± 0·001.

A few further tests have been made with an effusimeter; but there seems to be no ground for altering the opinion of this instrument already expressed in the 11th Report (p. 33)—namely, that while it will on most occasions yield results which are comparative, or even close to the correct result, it is liable to be erratic in its behaviour, and consequently cannot be relied upon for any but the roughest estimations of specific gravity.

Comparative Specific Gravity Determinations.

1.	2.	3.	4.	5.	6.
Differential Columns.	Weighing.	Analysis.	1–2.	1–3.	3–2.
·4855	·4925	..	−0·0070	..	..
·4856	·4916	..	−0·0060	..	..
·4846	..	·4903	..	−0·0057	..
·4922	·4911	·4914	+0 0011	+0·0008	+0·0003
·4852	·4874	·4848	−0·0022	+0 0004	−0·0026
·4769	..	·4768	..	+0·0001	..
·4800	..	·4816	..	−0·0016	..
·4921	·4963	..	−0·0042	..	..
·5002	..	·5000	..	+0·0002	..
Mean . .	..	..	−0·004	−0·001	−0·001

Each horizontal line in the above table refers to an independent gas sample. There is, therefore, no point in averaging columns 1, 2 and 3 respectively. In every case no importance attaches to the fourth figure in the values given; they are merely retained to prevent an accumulated error due to rounding-off at too early a stage.

The specific gravities by analysis are probably not in error by more than ± 0·002. With one exception, the specific gravity by the differential column apparatus and by analysis (column 5) agree within these limits, there being a tendency for the differential column method to yield slightly low results. On only two occasions have determinations been made by weighing and analysis on the same gas sample, and the comparisons show the specific gravity determinations to be in satisfactory agreement (column 6), weighing yielding, if anything, a slightly higher value. The probable error of the weighing method has been estimated above at ± 0·001 to ± 0·002. The mean difference between weighing and differential columns (column 4) is only 0·004, or about 0·8 p.ct. on gas of sp. gr. 0·49. The first two values in column 4, however, refer to determinations made at a comparatively early date when the technique of the method was not fully developed. It is probable, therefore, that 0·002 or 0·003 more nearly represents the mean difference in the two methods, while, if allowance is made for the difference between the results by analysis and by weighing, the mean discrepancy would be only 0·001 or 0·002. The differential column method is liable to certain small errors (*e.g.*, diffusion of gas and air into end boxes; removal of CO_2 by gauge water; unequal lengths of gas and air columns as gauge tilts; underestimation of temperature of columns), difficult to determine individually, but collectively amounting to the equivalent of 0·001 or 0·002 on the specific gravity, and usually acting in the direction of giving a low value. Bearing this in mind, the three methods may be regarded as yielding results in excellent agreement, usually within 0·002, although the discrepancy may occasionally reach 0·005—*i.e.*, 1 p.ct. on a typical town gas of sp. gr. 0·5.

Summarizing.

The weighing method cannot be regarded as suitable for technical work, and in practice is not likely to be more accurate than the other methods.

An accurate gas analysis will allow the specific gravity to be calculated to within ± 0·002, but an analysis of the requisite precision cannot be executed in less than one hour, even by a skilled operator.

The differential column apparatus provides a means whereby the specific gravity can be conveniently determined within ± 0·002 of its true value, and in a comparatively short time (say, 20 minutes). Our experience with the apparatus is thus in general agreement with that of the Fuel Research Board, as indicated in its Technical Paper No. 5.

Note on Definition of Specific Gravity of Gas.

If it is desired to express the specific gravity of a gas to 1 p.ct. or more closely, careful definition of the property in question is necessary. The specific gravity is usually defined as the ratio of the weight of 1 c.ft. of gas to that of an equal volume of air at the same temperature and pressure.

All our specific gravity values are quoted for dry gas compared with dry air; and the value so obtained is practically independent of the choice of any particular temperature and pressure, so long as these are the same both for gas and for air.

In practice, gas carries a certain amount of water vapour, frequently being fully saturated. The specific gravity is therefore sometimes defined as the ratio of the weight of 1 c.ft. of gas to that of 1 c.ft. of air at the same temperature and pressure, both being saturated with water vapour. This ratio, however, is not a constant, altering appreciably with temperature, and somewhat less so with the usual changes in barometric pressure; the effects being more marked the further the density of the gas departs from that of air. It is on account of this variation that the difficulty is not removed by specifying a standard temperature, pressure, and saturation—*e.g.*, 60° Fahr., 30 in. pressure, and full saturation for both gas and air, a point which is sometimes overlooked.

Effusimeters usually work with water as the confining liquid, both gas and air therefore being moist. The specific gravity obtained with such an instrument for a particular gas will therefore not be the same, even when the effusimeter is working satisfactorily, as by the three methods given in this report. The order of the difference is indicated below, and is about 1 to 1½ p.ct. for ordinary town gas.

Sp. Gr. of Gas on Basis $\frac{\text{Dry Gas}}{\text{Dry Air}}$ (Taking Dry Air = 1·00.)	Sp. Gr. of Gas on Basis $\frac{\text{Sat. Gas}}{\text{Sat. Air}}$ (Taking Sat. Air at 60° F. and 30 In. = 1·00.)	Sp. Gr. of Gas on Basis $\frac{\text{Sat. Gas at 60° F. 30 In.}}{\text{Dry Air at 60° F. 30 In.}}$
0·400	0·406	0·404
0·500	0·505	0·502
0·600	0·604	0·600

Given the dry gas value, which is a constant, it is $\frac{\text{dry air}}{}$ of course always possible to calculate the true density of the gas for any specified temperature, pressure, or degree of saturation.

It will be seen from column 3 of the table above that for ordinary town gas under average atmospheric conditions in this country, the specific gravity of the gas as frequently used (namely, moist) compared with dry air, differs but slightly from that of the dry gas compared with dry air. The use of dry air as the basis of comparison also has the convenience that data for the weight per c.ft. of dry air under various conditions of temperature and pressure can be obtained from tables, or may be very easily calculated.

APPENDIX I.

Notes on Precise Gas Analysis.

In our aeration and other investigations accurate gas analyses have been of vital importance. The following critical review of the methods of analysis we have employed may, therefore, be of interest. The notes apply to analyses conducted in a Bone-Wheeler apparatus of the usual dimensions (graduated length of pressure limb 600 m.m., capacity of burette to "constant volume" mark 75 c.c.), and assume an original gas pressure of about 500 m.m. mercury. All combustions were made

over copper oxide in a silica tube. The chief advantages of this method of combustion are that a much larger volume of gas can be burned than by explosion, thus giving greater accuracy in measurement; combustion can be extended over sufficient time to secure completion; there is no careful adjustment necessary to secure the right composition of an explosive mixture; no auxiliary supply or analyses of oxygen are required. The feature which distinguishes this process from those of other workers using copper oxide combustion lies in the evacuation of the combustion tube before and after combustion, using the gas burette as a mercury pump.

After critical examination, the method was extensively used by us for the determination of nitrogen, and was first reported upon, briefly but favourably, by Mr. James W. Wood in the First Report of the Gas Investigation Committee (1918, p. 76); no details, however, being there given. The apparatus was described at a later date by Dr. E. W. Smith, to whom we were indebted for the essentials of the process before publication ("Gas World," 1919, Vol. 71, p. 342), and was again described and illustrated by Dr. Parker in the 4th Report of the Gas Investigation Committee (pp. 316-317).

For the purposes of the present inquiry an attempt has been made to conduct gas analyses in which each constituent should be determined to within ± 0·05 p.ct., the final results being returned to the nearest 0·1 p.ct. To do this without making a number of analyses and averaging the results calls for very precise working, and certain systematic errors must be carefully eliminated.

There is no difficulty in reading the gas burette to ± 0·1 mm., *i.e.*, to ± 0·02 p.ct. on the gas volume; but even if a temperature correction is applied (and temperature variation is the commonest source of erratic results), this does *not* represent the precision of the analysis.

In 1918, 1919, and 1920, we were making very frequent determinations of nitrogen by combustion of the ***whole*** of the gas over copper oxide, and measurement of the residual nitrogen using this apparatus. Even at this early date it was observed that the nitrogen figure so obtained was consistently 0·3 to 0·5 p.ct. lower than when the nitrogen was similarly determined at the end of a complete analysis involving absorption of CO_2, hydrocarbons, O_2, and CO in the usual way, before combustion. Such accumulation of nitrogen was attributed to air or nitrogen dissolved in the reagents (evidence of the freedom of the apparatus from leaks being satisfactory), and an attempt was made to remove this by placing the reagents in communication with an evacuated vessel immediately before use. For obvious reasons this treatment cannot be applied either to bromine water or ammoniacal cuprous chloride solution.

Some reduction in the nitrogen discrepancy was effected, but the process was abandoned, as it complicated the analysis and introduced certain other small errors. Since 1918 the methods of manipulation have been improved, and the amounts of reagent have been reduced to the minimum compatible with satisfactory and reliable absorption. Nevertheless, the "direct" nitrogen is still always slightly less than the nitrogen residue at the end of a complete analysis; the discrepancy being remarkably constant, and usually lying between 0·2 and 0·3 p.ct., when a prescribed routine is followed. This amount should certainly be deducted from the nitrogen figure and added to the values for the absorbable constituents, but its distribution is open to discussion. In the absence of precise information on the point, it has been our custom to divide the discrepancy among the absorbable constituents, in proportion to the volume of reagent used for each—thus, CO_2: C_mH_n: O_2: CO, 1: 3: 2: 4. The most important correction is the addition of nearly 0·1 p.ct. to the unsaturated hydrocarbons, having regard to its effect upon C.V. and air requirement.

In certain analyses we were surprised to find small amounts of oxygen where complete absence of oxygen was expected. It was then found, by carrying out all the operations of a complete analysis with a sample of pure nitrogen or hydrogen, that if the bromine water was more than a few hours old, and had been exposed to light, there was an evolution of gas equal to 0·10 to 0·20 p.ct. of the gas taken —presumably oxygen, since it could afterwards be absorbed by pyro. Such evolution would seriously reduce the percentage of unsaturated hydrocarbons obtained by the analysis, and would give misleading figures for oxygen content in the next absorption (O_2), especially when controlling the small amounts of excess oxygen in purified gas, where revivification *in situ* is practised. This difficulty has been overcome by preparation of the bromine solution in small quantities immediately before use.

Upon a number of occasions the combustion after the removal of CO has been conducted in two stages—(i) at a barely perceptible red heat, (ii) at a bright red heat —with suitable pumping and measurement after each stage. Hydrogen burns quite readily over copper oxide at a dull red heat, and the contraction in volume is a direct measure of the amount of hydrogen present. After the second combustion at a higher temperature, there is usually an increase in volume, as might be expected if paraffin hydrocarbons higher in the series than methane (CH_4) were present. This determination has been made repeatedly; and the gas produced by steaming in the vertical retort installations at Meadow Lane, Leeds, for example, usually contains about 1·3 to 1·5 p.ct. of such hydrocarbons expressed as ethane (C_2H_6).

Ordinarily, the combustion is carried out in one stage, and the whole of the CO_2 produced is calculated as methane. The hydrogen is, therefore, under-estimated to the extent of the volume of C_2H_6 present. This is of no great consequence, however, for it can easily be shown that the density and air requirement of the gas calculated from the conventional analysis (*i.e.*, expressing the whole of the paraffin hydrocarbons as CH_4) gives precisely the same result as that where H_2, CH_4, and C_2H_6 are given separately, while the calorific value calculated from the conventional analysis is slightly too low to the extent of 0·7 B.Th.U. per c.ft. for each 1 p.ct. of ethane present.

At a temperature adequate for the combustion of methane there is a copious evolution of oxygen from the combustion tube, so that any instruction to carry on the pumping of the tube until a vacuum of, say, 0·5 m.m. is attained, is useless. Such oxygen would give too high a value to the nitrogen, and a correspondingly low value to the hydrogen figure in a one-stage combustion, the error often reaching 5 p.ct. There are two ways of dealing with this matter. The first is to follow the final CO_2 absorption with pyro, deducting the oxygen found from the nitrogen, and adding it to the hydrogen. An alternative plan due to Dr. Parker is to complete the combustion and then extinguish the burner heating the tube, continuing, however, to pass the gas backwards and forwards through the tube until it falls below a dull red heat. This usually takes about 3 minutes, and the oxygen is re-absorbed practically quantitatively. The tube is then pumped off as usual. This latter scheme is admirable except when gases are being treated in rapid succession for determination of nitrogen only, when it is perhaps more convenient to keep the tube hot and absorb the oxygen and CO_2 together, with alkaline pyro, before measuring the nitrogen.

Another irregularity of the copper oxide combustion gave some trouble in making precise determinations of air-gas ratios for burner mixtures, which, it will be recalled, depend upon accurate determinations of the CO_2 produced per cubic foot of the gas in use and of the mixture formed respectively. Analyses were always made in duplicate, and it was observed that, whenever a freshly oxidized combustion tube was used, or whenever a CO_2-in-mixture determination preceded a determination of the CO_2 produced per c.ft. of gas, the CO_2 obtained was lower than in the confirmatory analysis which followed on another portion of the same gas sample. The discrepancy was of the order of 0·3 p.ct., and was therefore too serious to neglect. It will be realized that the residual atmosphere at the end of an analysis of a town gas containing 20 p.ct. of methane and 10 p.ct. of nitrogen will consist of 66 p.ct. by volume of CO_2; while that from the combustion of the original gas, no constituents having been absorbed, will contain over 80 p.ct. of CO_2. The gas burette

and its connections are kept moist in the first place, and there is, in addition, the water which is produced by the combustion of the hydrogen and hydrocarbons of the gas. These conditions must of necessity favour the retention of a certain amount of CO_2, despite the reduced pressure in the apparatus at this stage, and it is surprising that the amount retained is so small. If the CO_2 is absorbed and the CO_2–free residue (augmented by nitrogen or air if necessary to give an amount convenient to manipulate) is re-circulated through the combustion system and pumped off again, an amount of CO_2 will be recovered upon absorption with potash which corresponds closely, but not exactly, with the CO_2 discrepancy in the consecutive analyses. Such "recovered" CO_2 should plainly be added to the larger amount already determined. It is not clear whether any corresponding correction should be made to the H_2, CH_4, and N_2 in a complete gas analysis, however, and on what basis. This will depend upon whether the CO_2 is dissolved or is present as gas in the combustion tube and its connections when the earlier measurements are made. When, as in practice, a number of analyses of gases of approximately the same character follow one another, the amount of CO_2 retained in the apparatus is approximately constant, so that the error would only appear on the first of the series. Even this might be avoided by a preliminary blank or "conditioning" combustion, no measurements, of course, being necessary. Where, as in our air-gas ratio determinations, however, gases giving widely different CO_2-concentrations in the residue after combustion follow one another, this plan cannot be followed, and it has proved necessary frequently to determine this small amount of "recovered" CO_2 and employ an appropriate correction. The same considerations would apply, with modifications, to analyses conducted by explosion, and are not peculiar to combustion over copper oxide.

It is not possible to calculate the specific gravity of a town gas from an analysis without knowing something of the nature, as well as the quantity, of the unsaturated hydrocarbons. In our analyses no attempt has been made to separate or identify these by the use of several reagents of different chemical composition or strengths. Instead, however, an attempt has been made to determine their combined effective molecular weight, and hence their density. To do this, two partial analyses have been conducted. First, a direct combustion is made of a portion of the gas sample with a determination of the total CO_2, present and produced. Secondly, another portion of the sample is taken, the CO_2 present is determined, hydrocarbons are removed, and the residue is then completely burned. It is thus possible to determine the sum of the CO_2 present and that produced from all constituents except the hydrocarbons. The difference in the total CO_2 produced in the two determinations is that due to the combustion of the unsaturated hydrocarbons. Now one volume of C_mH_n yields $_m$ volumes of CO_2. From the above data, therefore, $_m$ is readily determined. This method does not give a value for $_n$, but it will usually lie between $_m$ and $2_m + 2$. The maximum variation in density due to the choice of a value for between these extreme limits is ± 5 p.ct; and as the amount of hydrocarbons in town gas is usually small, this approximate estimate of their density is sufficient. In a considerable number of analyses of town gas of C.V. 450 to 500 B.Th.U. gross per c.ft. which we have made by this method in Birmingham (1918-20), and Leeds (1924-5), the value of $_m$ keeps very close to an average value of 2·7. Assuming C_mH_n to be C_mH_{2m}, this leads to a mean density of 12·3 for the unsaturated hydrocarbons (air = 1·00).

APPENDIX II

CALCULATION OF AIR INJECTED AND PRODUCTS OF COMBUSTION DRAWN IN WITH PRIMARY AIR.

Assuming that the gas and air are both dry and the air free from CO_2,

Let a = vol. of CO_2 present in 1 vol. of dry gas.
b = ,, ,, ,, produced from combustion of 1 vol. of dry gas (including CO_2 already present—*i.e.*, a).
c = vol. of CO_2 present in 1 vol. of dry mixture of air and gas as determined by analysis.
d = vol. of CO_2 produced from combustion of 1 vol. of dry mixture over CuO. (including CO_2 already present—*i.e.*, c).
e = vol. of dry products of combustion from 1 vol. of dry gas (calculated from analysis and assuming all water condensed out).
f = vol. of water vapour produced by combustion of 1 vol. of dry gas.
x = vol. of dry air injected by 1 vol. of dry gas.
y = vol. of dry products of combustion drawn in per volume of dry gas.

Then $$a + y\frac{b}{e} = c\,(1 + x + y) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

And $$b + y\frac{b}{e} = d\,(1 + x + y) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Whence $$x = \frac{ade - ab + bc - bce + b^2 - bd}{bd - bc} \quad . \quad . \quad . \quad (3)$$

And $$y = \frac{e}{b}\left(\frac{bc - ad}{d - c}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

If CO_2 is present in the air of the room (as distinct from that produced in the neighbourhood of the burner by combustion), then it can be shown that (3) can be expressed in the form:

$$x = \frac{ade - ab + bc - bce + b^2 - bd}{b\,(d - c) - eg\,(d - c)} \quad . \quad . \quad . \quad . \quad . \quad (3A)$$

And $$y = \frac{ae - ce - (ce - eg)\,x}{ce - b}$$

where g is the CO_2 present in unit volume of air.

If the air of the room is free from CO_2, and there is no injection of products of combustion with the primary air, the above expressions reduce to the very simple form—

$$x = \frac{b}{d} - 1.$$

Prof. J. W. COBB, in introducing the report, said: Mr. James Wood has been following-up the subject of the aeration of burners. At first the treatment was of a very general character; but that was followed-up last year by a more special study of some of the burners used in heating appliances—such as the gas fire and ring burner. This year the study has been carried further, and typical lighting burners have been subjected to careful examination. The results are presented in this report. You will notice that at the beginning of the report we have followed what is now our usual custom of placing first an introduction and a summary, in which a general account is given of the experiments and their results. The mass of information in detail which has accumulated in the progress of the work, and is necessary for its complete understanding and setting-out, is then placed later in the body of the report, where it can be followed-up by an interested reader. I may say that much experimental ingenuity has had to be expended to enable these results to be obtained, largely because the lighting burner is a much smaller and more delicate thing than (say) a ring burner. Possibly the most remarkable result from one point of view (perhaps I call it that because it surprised me and Mr. Wood also) was that the amount of primary air injected by an ordinary lighting burner, working normally with a good illumination, was only about half the total air requirement. The significance of this is that obtaining effective illumination from the burner must depend very much on how the rest of the air is supplied; and so it shows what importance must attach to the accessory fittings, which help to determine the way in which the secondary air is supplied.

One of the essential factors in the whole of this study of aeration has been the density of the gas. The determination by the effusimeter is apt to be erratic; while the making of a complete gas analysis is a very tedious process. But the gas engineer should have a means of determining density, and particularly changes in density, of the gas that he supplies. Mr. Wood has given both time and thought to this determination, and has examined in great detail the applicability of the method which, in essence, has been known for a long time, and a form of which was described by Mr. Blackie, of the Fuel Research Board. Mr. Wood finds himself able to describe that method, when applied with proper precautions, as being accurate and comparatively rapid in working.

Mr. JAMES W. WOOD then presented an abstract of the report, upon which there was no discussion.

Prof. COBB: I quite appreciate the difficulty of framing criticism of a report of a highly technical character at short notice. But I should be very sorry if on this account we were deprived of any criticism, which members can send forward to me in writing.

The report was adopted.

FOURTEENTH REPORT OF THE RESEARCH SUB-COMMITTEE OF THE GAS INVESTIGATION COMMITTEE.

THE EXPERIMENTAL GAS PLANT AT LEEDS UNIVERSITY.

SIR CORBET WOODALL MEMORIAL.

Adopted by the Committee, May 21, 1925.

[For "General Introduction" see the Thirteenth Report.]

INTRODUCTION.

In September, 1917, Mr. Henry Woodall made the generous offer to erect and present to the University of Leeds an experimental carbonization plant in memory of his father, the late Sir Corbet Woodall. This offer was gratefully accepted by the Council of the University; but the conditions prevailing at that time prevented the carrying out of the project. When circumstances became more favourable, Mr. Henry Woodall commenced operations, and the plant was officially presented to the University at the opening ceremony held on March 26 last year.

The lay-out of the installation was designed by Mr. J. F. Scott after consultation with Professor Cobb and others. The original idea that the memorial should take the form of an experimental plant was due to Mr. W. T. Dunn, of the Institution of Gas Engineers. In the first instance, the suggestion was to erect one setting of retorts only, but the scheme grew until finally two settings, including both horizontal and vertical retorts, were installed. The cost greatly exceeded the first rough estimate; but so many friends of the late Sir Corbet Woodall expressed a desire to help, that it has been possible to erect the larger plant and to have a surplus in the form of an endowment for any future extensions and alterations. There are five companies with which Sir Corbet Woodall was specially connected, the Gas Light and Coke Company, the British Gas Light Company, the Tottenham District Light, Heat, and Power Company, the Bournemouth Gas and Water Company, and the Croydon Gas Company; and they have all been most generous in their help. Messrs. Humphreys & Glasgow offered a carburetted water gas plant, but it was decided that the make of gas for the smallest practical unit would be too great. Mr. A. G. Glasgow, however, insisted on giving a handsome donation. Messrs. Clayton, Son & Co., Ltd., of Leeds, who built the gasholders, scrubbers, purifiers, &c., made a substantial gift in money and supplied the apparatus on most advantageous terms. The Woodall-Duckham Company gave the setting of vertical retorts, Messrs. Gibbons Bros., Ltd., of Dudley, presented the horizontal setting, and Messrs. W. Parkinson & Co. were responsible for the gift of a meter. Messrs. Bryan Donkin installed the machinery in the exhauster house. All those concerned with the plant gave every possible assistance.

The first utilization of the plant has been made by the Gas Investigation Committee.

Dr. Parker and his assistants commenced operations last year, when the work at Birmingham had been completed. In the first place the many smaller fittings necessary in an installation required for investigations of the nature it was proposed should be conducted, were added; then gas making and carbonization trials on the horizontal retorts were carried out, and at the same time the performances of the condensing, scrubbing, purifying apparatus, &c., were examined. *The installation is not in any way a small scale model of a gas-works,* but has many features which differ greatly from usual practice. It was therefore necessary that preliminary trials should be carried out before a research programme designed towards the solution of definite problems could be commenced. The preliminary trials of the horizontal setting and of the condensing and purifying plant, &c., have been completed, and some alterations have been made. As a result of these tests and alterations, the suitability of the horizontal setting and auxiliary plant as a carbonization unit has been established, and tests of the vertical retort setting are now in progress.

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See Illustrations appended.

The Corbet Woodall experimental gas plant occupies a site, provided by the University, adjoining the Department of Fuel and Coal Gas Industries. The general arrangement of the plant is shown in plan in Fig. 1. The installation includes a setting of two horizontal retorts, a setting of two vertical retorts, and the usual condensing and purifying plant.

The setting of horizontal retorts is housed in the main building, and the vertical retorts are situated in an open yard. The gas from the horizontal retorts or the vertical retorts passes through the pipes A or B, provided with valves, to the air condenser, whence it travels through the exhauster to the scrubbers, the purifier, the meter, and the holders. Tar and liquor collecting pots are provided at the positions marked C, D, and E; and drain cocks are placed at the points marked F, G, and H. A gas-fired boiler is situated near the vertical retort setting; the boiler feed tank is adjacent to the air condenser, and a water meter is placed at position J. A photograph of the front of the plant is shown in Fig. 2, Plate 6. In the foreground is the horizontal retort house, and behind this are the vertical retorts, the exhauster house, &c. In the background the framework of one of the gasholders can be seen.

Horizontal Retorts.—The arrangement of the horizontal setting and the method of heating are shown in Fig. 3, Plate 1, which gives vertical and horizontal sections and elevations. The setting, which was designed and erected by Messrs. Gibbons Brothers, Ltd., of Dudley, contains two fireclay retorts of circular section. Each retort is 6 ft. in length and has an internal diameter of 12 in. From Fig. 3 it may be seen that the setting consists of two exactly similar halves with one common chimney for the waste gases.

Each retort is heated by six burners supplied with coal gas—usually town supply—and with air from a compressor situated in the exhauster house. The amounts of air and fuel gas for each burner are controlled by separate cocks, and the two gases enter a mixing chamber before travelling upwards to the burner nozzle. The amount of air which can be supplied under pressure is less than that required for complete combustion, if lighting back and overheating of the burner are to be prevented. An auxiliary supply of secondary air is therefore necessary. The burner tubes projecting vertically from the mixing chambers are narrower than the openings in the brickwork through which they pass, with the result that some auxiliary air is drawn upwards around the tubes. When maintaining the retorts at a temperature of about 1000° C., a further quantity of auxiliary air is supplied through holes of 1¼ in. diameter in the inspection doors marked C in Fig. 3. These openings are fitted with 1-in. nipples so that they can be closed when desired by means of caps.

Each burner is placed vertically below a silica brick supporting the retort, which is thus not submitted to the direct cutting action of the flame. The burning gases are deflected by the silica brick in such manner that they are divided into two streams travelling on opposite sides of the retort. The products of combustion then travel over the top of the retort and past three damper plates to enter a

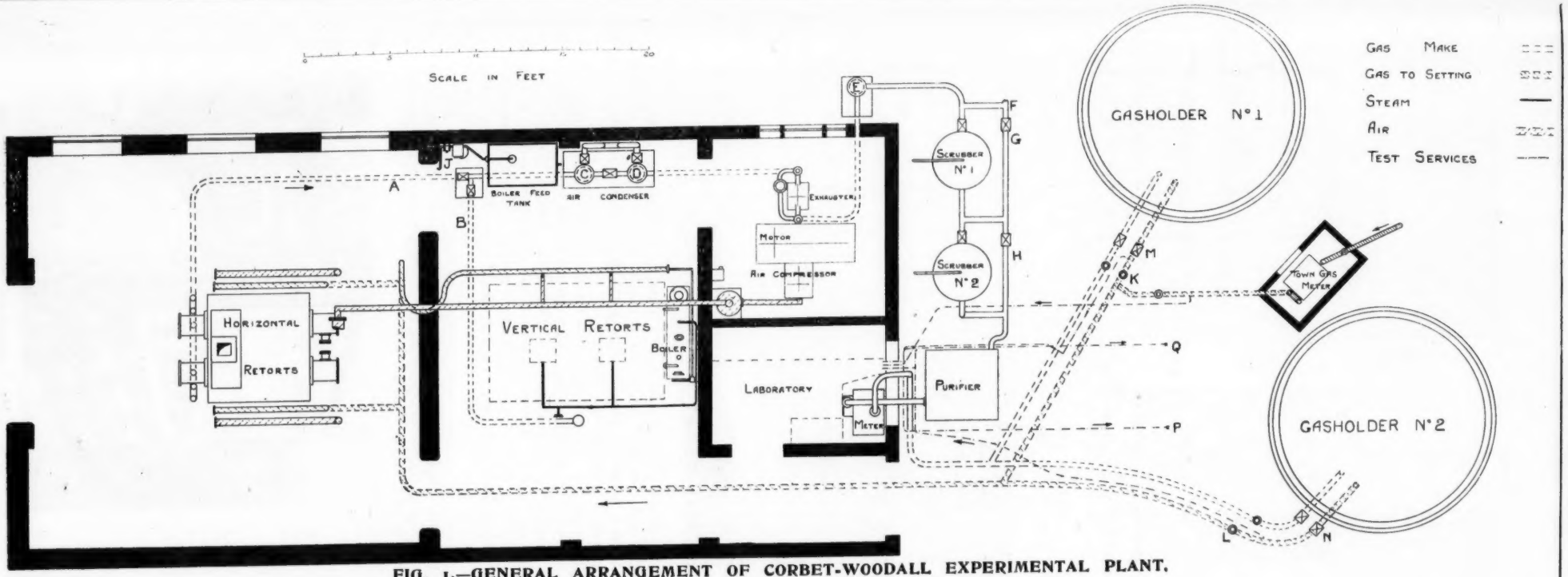


FIG. 1.—GENERAL ARRANGEMENT OF CORBET-WOODALL EXPERIMENTAL PLANT.

horizontal waste-gas flue on their way to the chimney, which is also provided with dampers. The air supplied to the burners is preheated by passage through a cast-iron pipe of 6 in. diameter, placed horizontally in the waste-gas flue above the retort.

It has already been mentioned that the retorts are 6 ft. in length. The end walls of the setting are 9 in. in thickness, so that the length of retort exposed to the heating gases is 4 ft. 6 in. Experience has shown that uniform heating of the retort can be secured over a total length of about 4 ft. This section of each retort, which can be kept at a uniform temperature, has a capacity of approximately 120 lbs. of coal with a heavy charge.

The mouthpiece of each retort projects 1 ft. 6 in. from the front of the setting, and is provided with a self-sealing door. The arrangement of the gas off-takes is shown in Fig. 4, Plate 2. According to this arrangement, the gas leaves the retorts by short descension pipes and then passes upwards through ascension pipes, each about 5 ft. in length, before again travelling downwards

Fig. 2.—Horizontal Retort House.

to the foul gas main underground. The lower end of each ascension pipe is fitted with an extension piece, 12 in. in length, which is sealed in a measured quantity of water. The retort valves are placed in the pipes leading from the upper ends of the ascension pipes to the main below ground level. The aim in this design is to remove all pitch by cooling the gas before it reaches the valves. This object has been fully achieved; for trials which have been carried out have proved that there is no deposition of solid matter either in the ascension pipes or any succeeding pipes. Pitch is deposited in a semi-plastic condition in the crosses immediately below the retort mouthpieces, but these deposits are readily removed when the retorts are opened for charging and discharging. Accumulation of pitch and consequent stoppage is thus avoided. The higher boiling fractions of tar condense out in the ascension pipes and flow down into the seal pots; and this steady downward flow ensures the ascension pipes being kept free from solid matter.

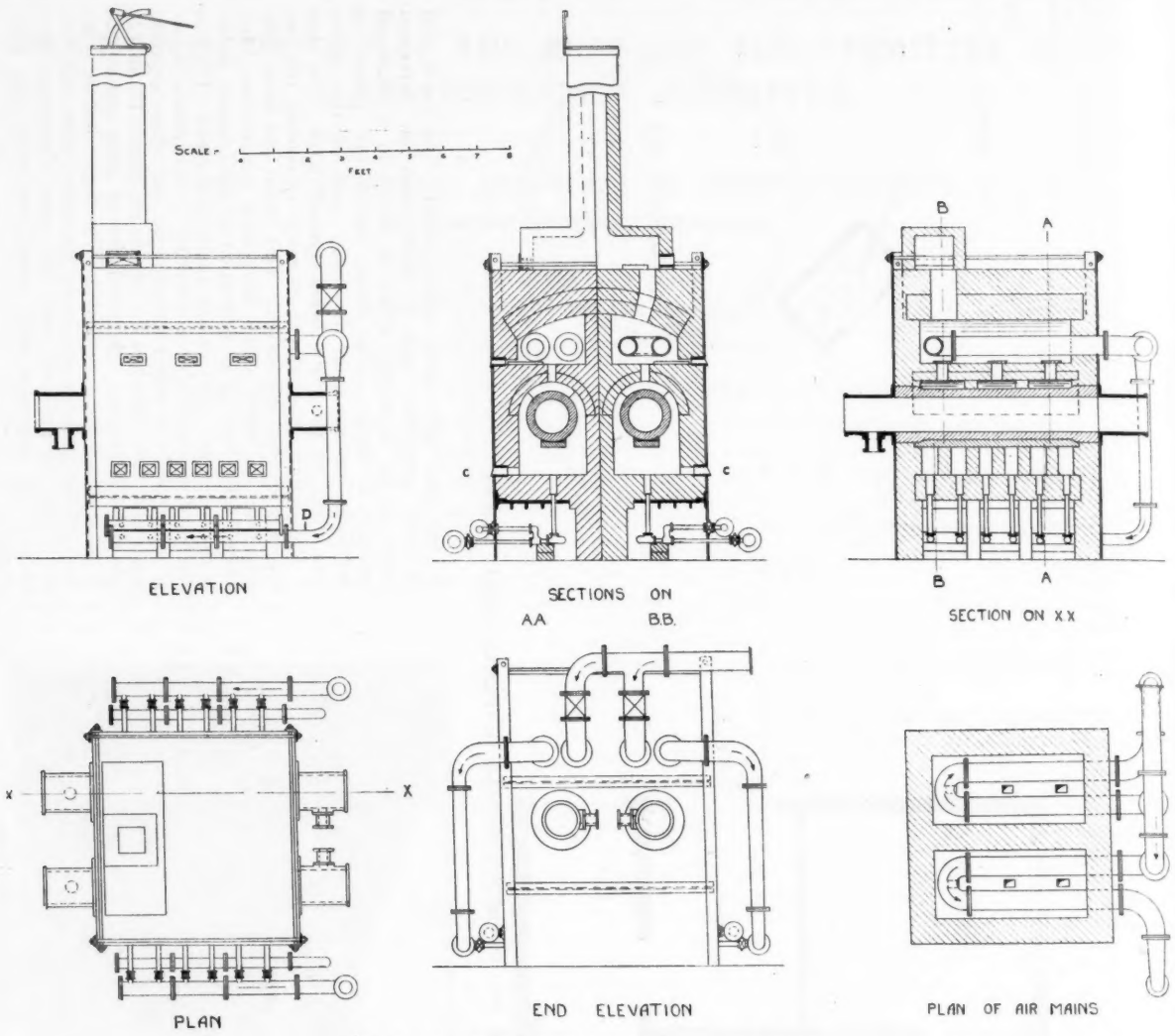


FIG. 3.—HORIZONTAL RETORT SETTING.

The fittings attached to the discharging ends of the retorts and the dispositions of the air supply pipes at this end of the setting are shown in the photograph, Fig. 5, Plate 6, and in several of the diagrams of Fig. 3. The metal castings bolted to the retorts are of the same dimensions as those at the front of the setting, and are fitted with self-sealing doors. Each casting is provided with a short length of 3 in. pipe on the side nearer the middle line of the setting. When normal carbonization tests are in progress, these pipes are closed by means of blank flanges, but if desired the blank flanges may be removed and the retorts connected by means of a short piece. This latter arrangement would prove useful in experiments in which it might be desirable to preheat gases or steam in one retort before passage through a charge undergoing treatment in the second retort; or it might be used for the production of water gas in one retort for passage through a charge in the second retort.

Vertical Retorts.—The vertical retort setting, which is situated in the open yard behind the horizontal retort house, was designed and erected by Messrs. Woodall Duckham, Ltd. The arrangement and method of heating are shown in Figs. 6 and 7, Plates 2 and 3, which give horizontal and vertical sections and elevations. Each retort, which is of silica material, is 8 ft. 7½ in. in length (excluding the coke chamber), and tapered from 8½ in. diameter at the top to 1 ft. 3 in. diameter at the bottom. The coal is fed into the retorts from the small hoppers at the top through close-

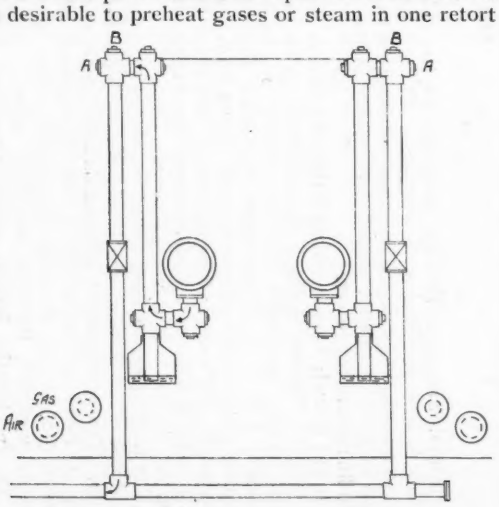


Fig. 4.—Horizontal Retort Setting—Gas Off-Takes.

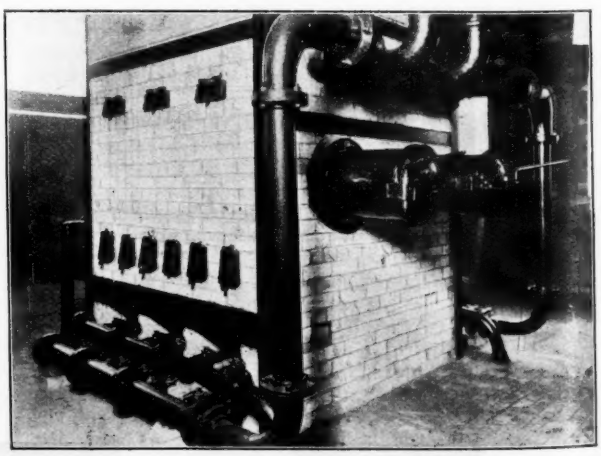


Fig. 5—Horizontal Setting. Discharging End.

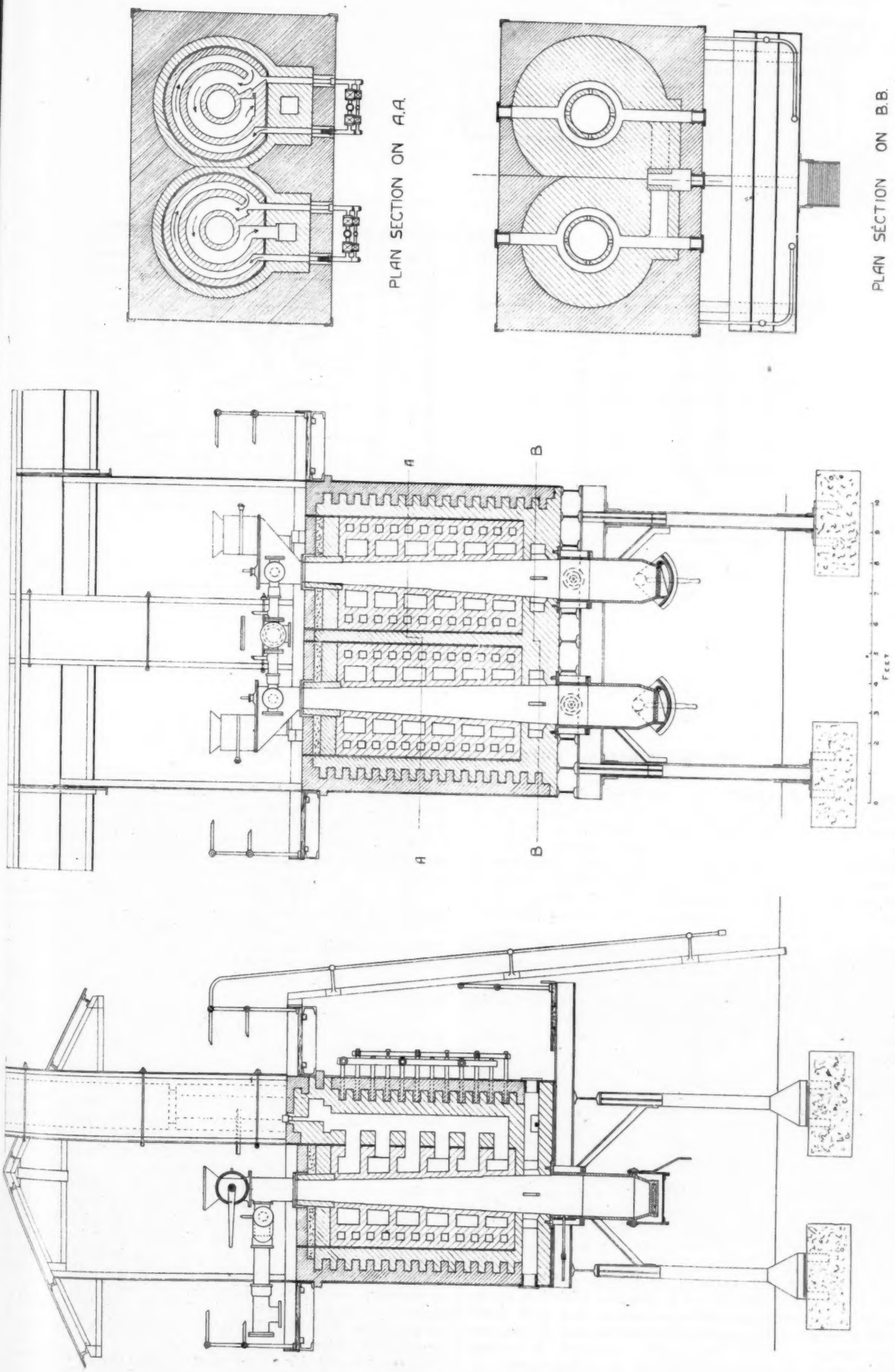


FIG. 6.—VERTICAL RETORT SETTING—SECTIONS.

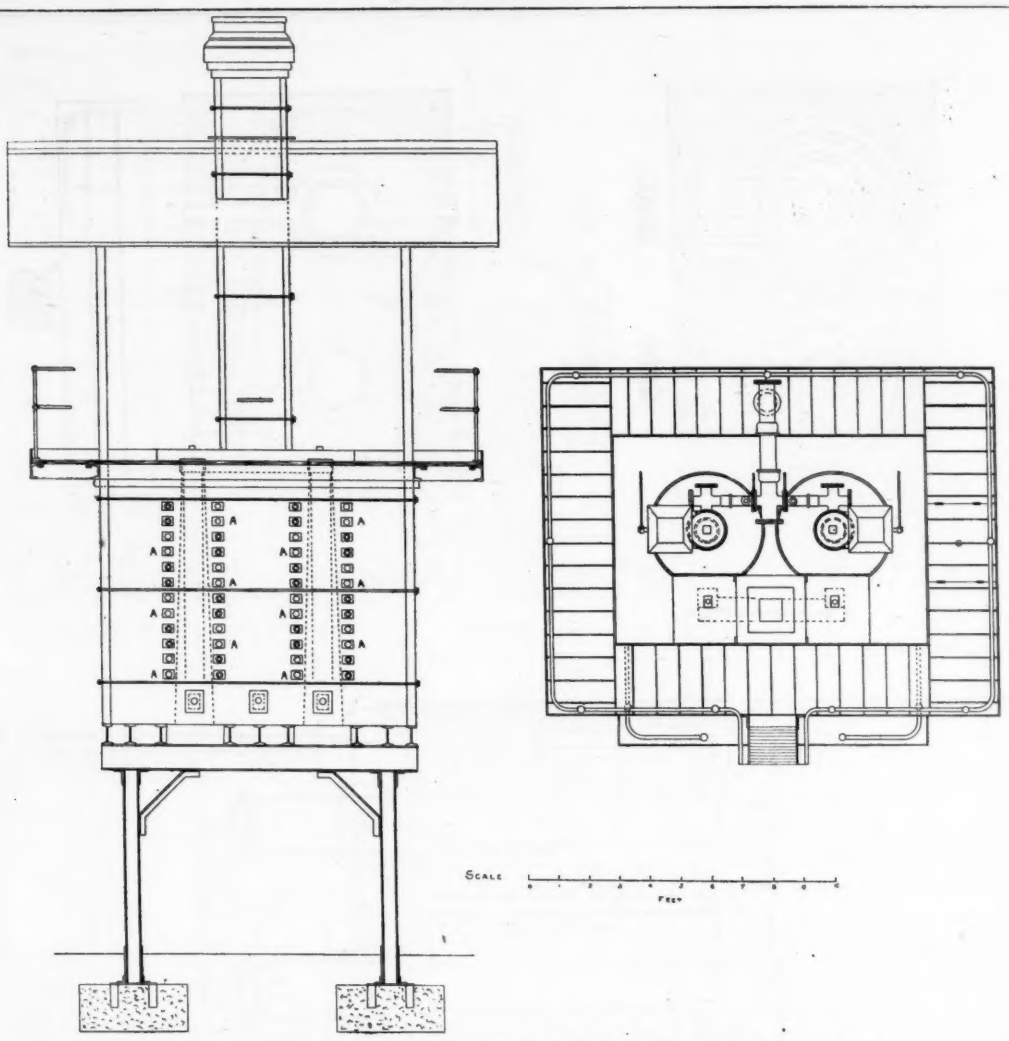


FIG. 7.—VERTICAL RETORT SETTING—ELEVATION AND PLAN.

fitting cylindrical valves. The coal is raised by chain and blocks to the charging platform, which is covered by a galvanized roof. The coke-cooling chambers at the lower ends of the retorts are 1 ft. 4 in. square section, and approximately 3 ft. 6 in. in length. No rotary extractor of the type usually found with continuous vertical retorts is provided; but the charge undergoing treatment rests on a hinged plate situated at the bottom of the cooling chamber. The coke chamber is water sealed in a movable quadrant provided with handle. When the quadrant is moved to one side, the hinged plate falls; and the retort may thus be discharged until the desired quantity of coke has been removed, when the coke chamber is again closed by the rapid movement of the quadrant to its original position.

The setting is heated by coal gas, usually town supply, and the air necessary for combustion is provided by the compressor situated in the exhauster house. The heating chambers for each retort are arranged in six circular horizontal tiers, each tier being under separate controls to enable the temperatures to be adjusted as required through the 6 ft. length of retort exposed to the combustion chambers. The capacity of the heated portion of each retort is approximately 2 cwt. of coal. The air and fuel gas supplied are preheated before mixing, by passage through separate flues surrounding each combustion chamber. The waste gases are collected in vertical flues communicating with a brick chimney which extends to a height of 16 ft. above the charging platform. The arrangement of the various flues is clearly shown in the diagrams of Fig. 6.

The lower end of each retort is provided with four openings which communicate with a common flue with damper adjustment. This enables the two retorts to be connected together at their lower ends, if desired. It is thus possible, as in the horizontal setting, to preheat gases or steam in one retort prior to passage through a charge undergoing treatment in the second retort, or to produce water gas in one retort for passage through a charge in the second retort. Means are provided for taking away the crude gas from either the upper or lower ends of both retorts. In both cases the crude gas passes downwards immediately after leaving the retorts, so that liquid products can be collected without having undergone further decomposition as a result of reflux action back into the retorts.

The air and fuel gas services at the front of the setting are shown in elevation in Fig. 8, Plate 3. A photograph of the front of the vertical retort unit is given in Fig. 9, Plate 6, which includes the charging platform, the burner-control stage, and the pipes supplying fuel gas and air to the setting. Fig. 10 is a view of the discharge end of the retorts.

Air Condenser.—The crude gas from the horizontal or vertical retort setting travels by the 3-in. main A or B (*vide* Fig. 1), situated below ground level, to the air condenser, which may be arranged in circuit or by-passed by suitable manipulation of the three valves provided. The construction of the air condenser and the dispositions of the valves are shown in Fig. 11, Plate 3; and a view of the upper portion may be seen on the left of the photograph, Fig. 9. The condenser is made up of lengths of 3-in. diameter pipe. The total length of air-cooled pipe is 46 ft., so that the cooling area is approximately 36 sq. ft. There are two tar and liquor collecting pots below ground level, the first at the inlet of the air condenser and the second at the outlet. Each pot has an internal diameter of 8 in., and its capacity to the bottom of the gas main is approximately 1·8 gallons. A drain cock is provided in the middle of the condenser, as shown in Fig. 11. When the plant is in operation this drain cock, which is left open, is fitted with an extension piece sealed in a vessel containing a measured quantity of water.

Exhauster and Air Compressor.—From the air condenser the cooled gas travels to an exhauster situated in a small room behind the vertical retort yard. The exhauster, which was supplied and installed by Messrs. Bryan Donkin & Co., Ltd., of Chesterfield, has a rated capacity of 800 c.ft.

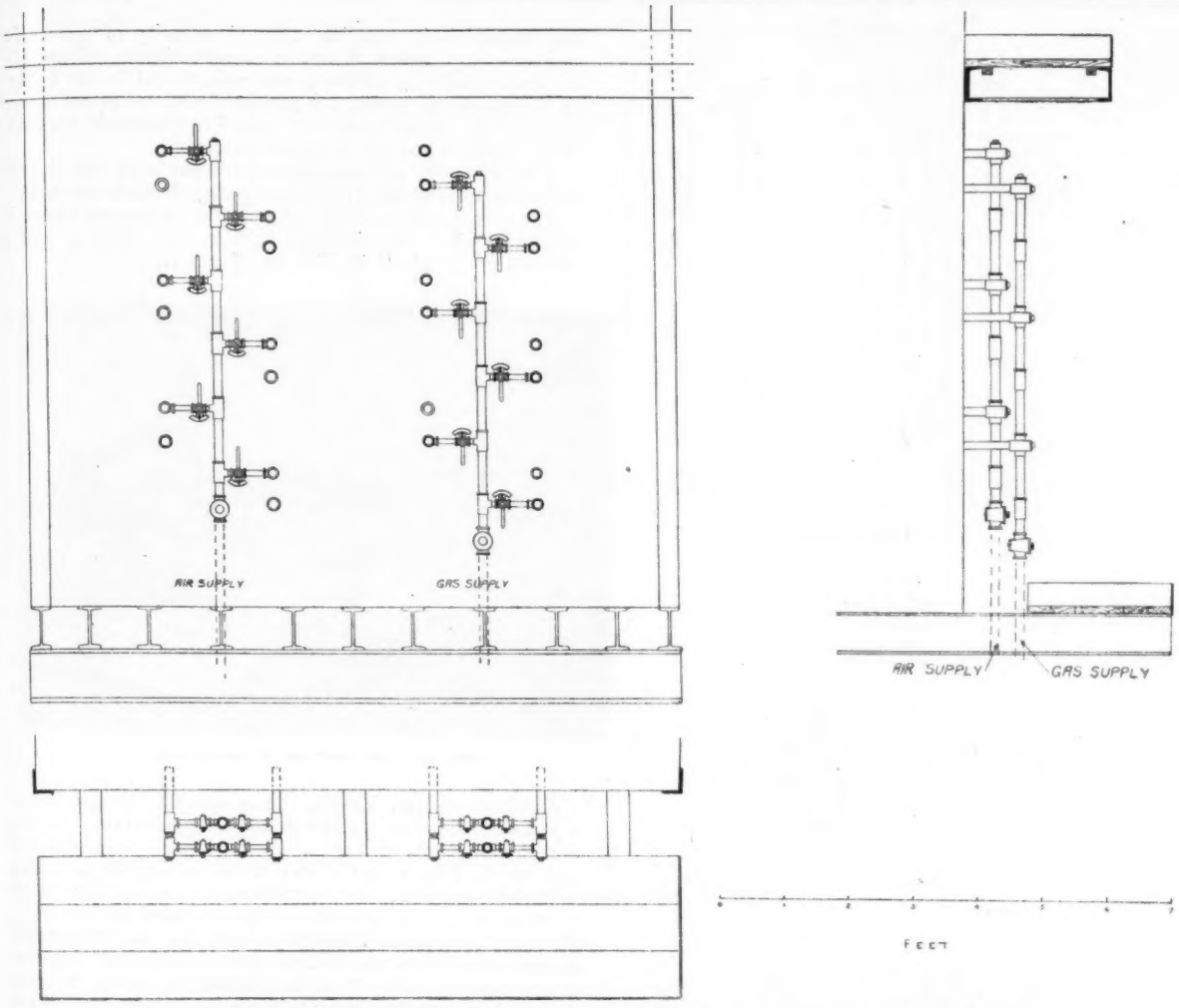


FIG. 8.—VERTICAL RETORT SETTING, AIR AND FUEL GAS SERVICES.

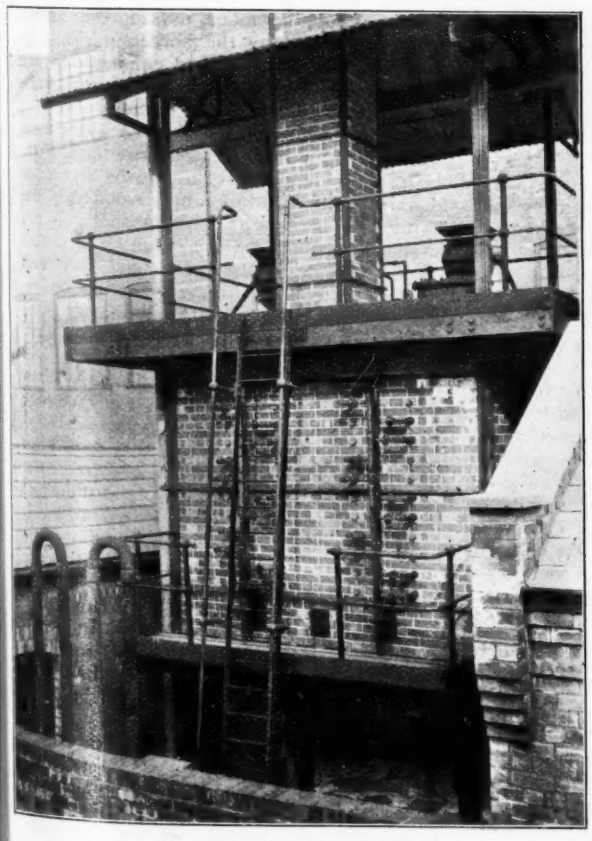


Fig. 9.—Vertical Retort Setting.

of gas per hour at 240 revs. per minute. It is belt-driven from a shaft operated by a 5-H.P. electric motor, the current for which is town supply through a switch with no-volt release. The motor, made by Messrs. Parkinson & Co., of Guiseley, Leeds, is designed to operate with 200 volt two-phase alternating current, 50 cycles per second, and with a shaft speed of 940 revs. per minute. The speeds of the motor and exhauster are not adjustable, but the

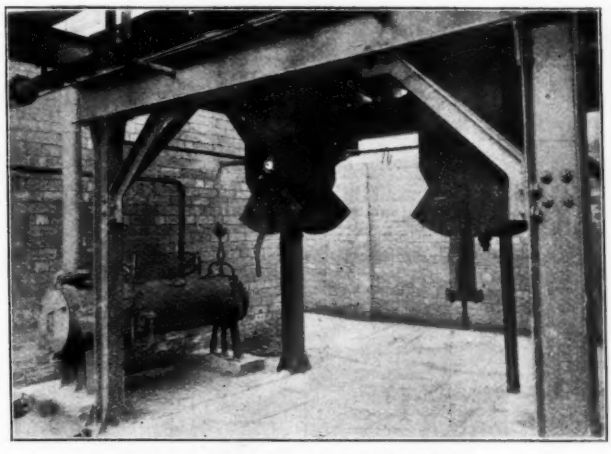


Fig. 10.—Vertical Setting, Coke Chambers.

pressure of gas at the inlet to the exhauster is controlled by means of a by-pass governor with balanced bell and conical valve.

The air required for heating the two retort settings is provided by a compressor which is also situated in the exhauster house, and was supplied and installed by Messrs. Bryan Donkin, Ltd. The compressor is belt-driven from

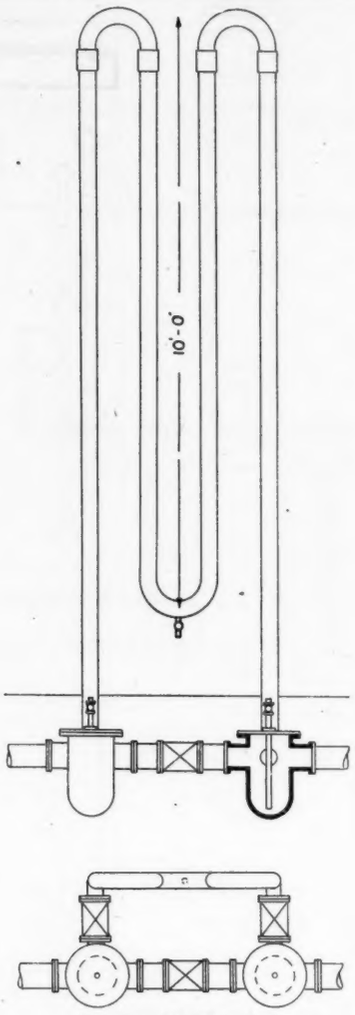
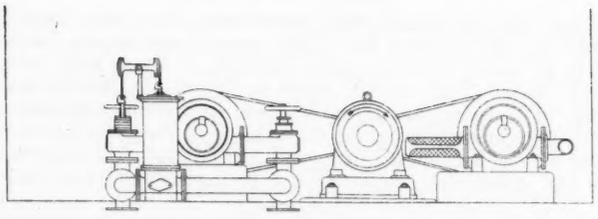


Fig. 11.—Air Condenser.



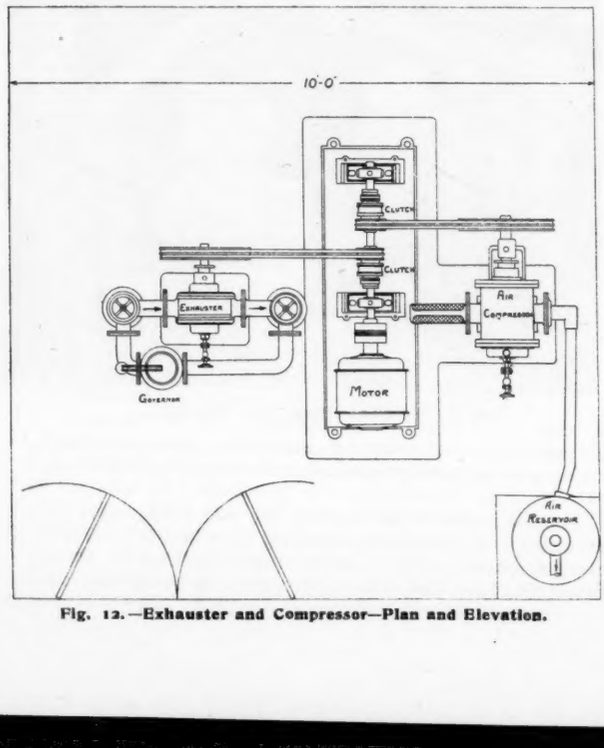


Fig. 12.—Exhauster and Compressor—Plan and Elevation.

the motor shaft, and has a rated capacity of 4000 c.ft. per hour at a speed of 255 revs. per minute. From the compressor the air enters a reservoir placed in one corner of the exhauster house, and provided with weighted escape valve at the top and a mercury gauge to enable the pressure to be regulated to the required amount.

The exhauster and compressor are put in or out of gear by means of separate Hele-Shaw patent friction clutches.

The arrangement of the plant in the exhauster house is shown in plan and elevation in Fig. 12, Plate 3, and a photograph is given in Fig. 13, Plate 6.

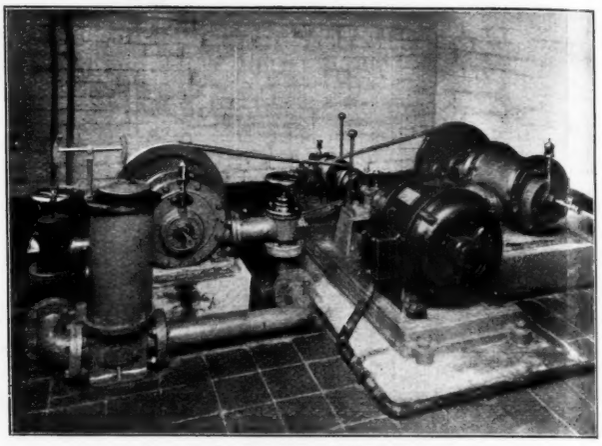


Fig. 13.—Exhauster and Air Compressor.

Scrubbers.—After leaving the exhauster, the gas is conveyed to two tower scrubbers erected by Messrs. Clayton, Son & Co., Ltd., of Leeds. A collecting pot is placed at position E, Fig. 1, in the service connecting the exhauster with the scrubbers. Both scrubbers are packed for a depth of about 5 ft. with porcelain rings supplied by Messrs. J. Macintyre & Co., of Burslem. Each ring is 1 in. external diameter and 1 in. depth, and the thickness of the porcelain is 1-10 in. The scrubbers, which are shown in elevation and section in Fig. 14, Plate 4, are 10 ft. high and 3 ft. internal diameter, and are fitted with water supply pipes and perforated plate water distributors at the top. The internal capacity of each scrubber, making due allowance for the volume occupied by the porcelain rings, is approximately 60 c.ft. The valves and connections are so arranged that either scrubber may be used alone, or the two in series, or both may be cut out of circuit.

Purifier.—The oxide purifier adjacent to the scrubbers (*vide* Fig. 14) consists of a box 4 ft. square and 4 ft. deep. The top cover is made gas-tight by means of rubber jointing material. The purifier contains three wooden grids, so that the purifying area is 48 sq.ft.; the internal volume, allowing for the space occupied by the oxide, is approximately 50 c.ft. A view of the scrubbers, purifier, and wall crane is given in the photograph, Fig. 15, Plate 6.

Meter.—The purified gas is measured in a 100-light wet meter supplied by Messrs. Parkinson & Cowan, Ltd. The meter, which is situated in the small laboratory adjoining the exhauster house (*vide* Fig. 1), contains a Warner and Cowan drum designed to compensate for any change in water level.

Holders.—From the meter the gas is led to one or other of two gasholders, occupying the positions shown in the plan, Fig. 1. Each holder consists of one column-guided lift of 1100 c.ft. capacity and a steel tank above ground level. The construction of the holders is shown by the diagrams in section and elevation in Fig. 16, Plate 4. Indicators are provided to enable the rise or fall of each holder to be conveniently measured at any time. The volume of the crown of each holder is 34 c.ft., and the capacity per inch rise is 9·25 c.ft. The pressure thrown by the bell is approximately 4·5 in. water gauge, and the volume above the water line when the bell is in its lowest position is about 120 c.ft.

Boiler and Steam Supply.—Provision is made for experiments on steaming, if these should be required. The steam is raised by means of a small Kirke gas-fired boiler, supplied by Messrs. Spencer Bonecourt, Ltd. This boiler, which appears in the photograph, Fig. 10, and is shown in section and elevation in Fig. 17, Plate 4, is designed to

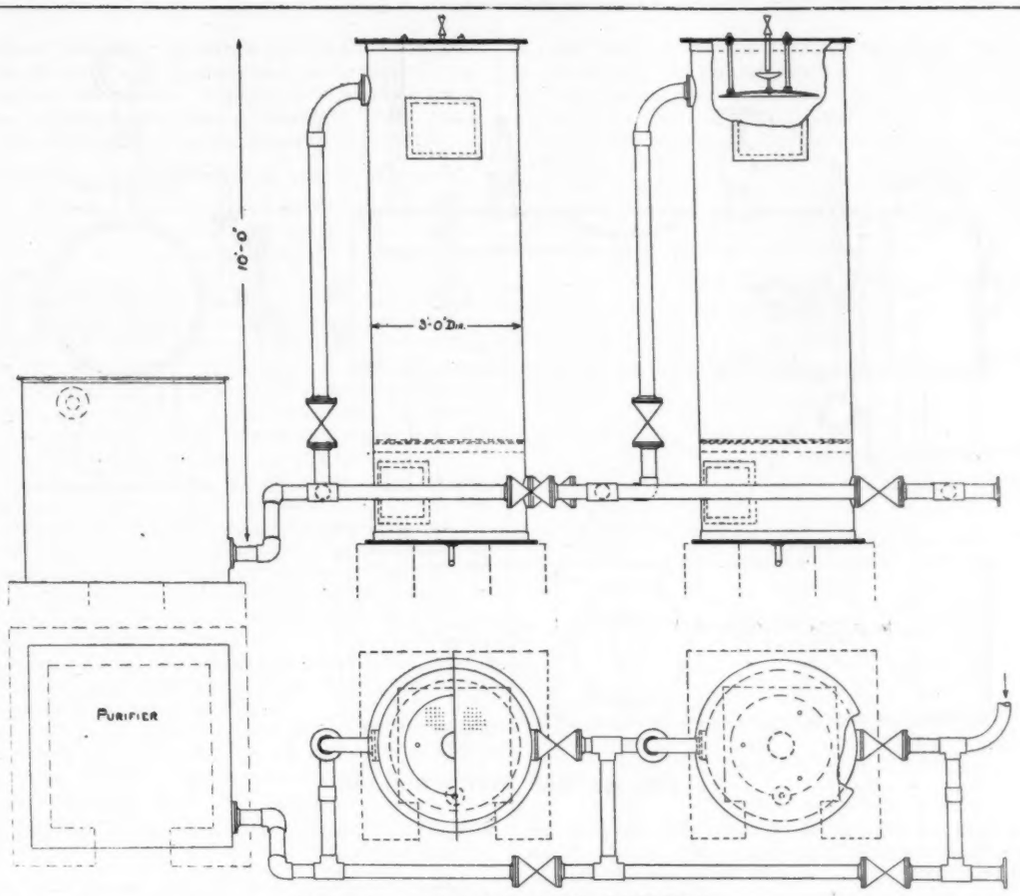


FIG. 14.—SCRUBBERS AND PURIFIER.

raise steam at a pressure of 120 lbs. per sq. inch. The water is fed into the boiler by means of a half-inch Simplex injector. From trials which have been made, it has been found that, with the maximum gas supply as at present arranged, the boiler raises approximately 50 lbs. of steam per hour at 100 lbs. pressure from water at ordinary temperature; the consumption of gas of a gross calorific value of 470 B.Th.U. per c.ft. is about 180 c.ft. per hour.

The services from the boiler are so arranged that steam may be admitted to the vertical retorts at either the upper

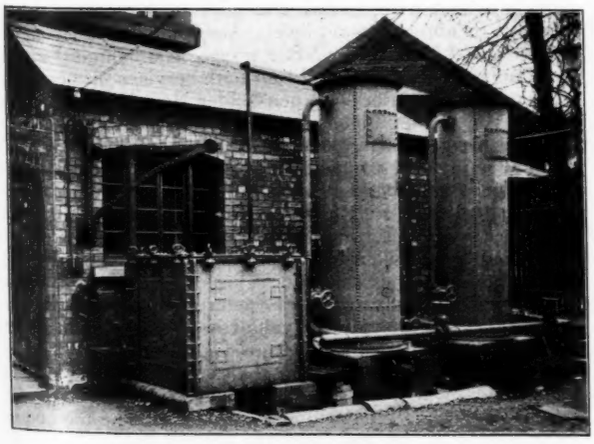


Fig. 15.—Scrubbers and Purifiers.

or the lower ends. In addition, steam may be supplied to the gasholder tanks through injectors which ensure the circulation of water. This apparatus has been installed to prevent the freezing of the water in the tanks during cold weather.

Measurements and Weighings.

Coal and Coke.—The coal supplied to the retorts is weighed in covered galvanized receptacles, on a portable platform machine supplied by Messrs. W. & T. Avery, Ltd. The beam of the machine is graduated in two scales to a maximum of 500 lbs. One division on the scale cor-

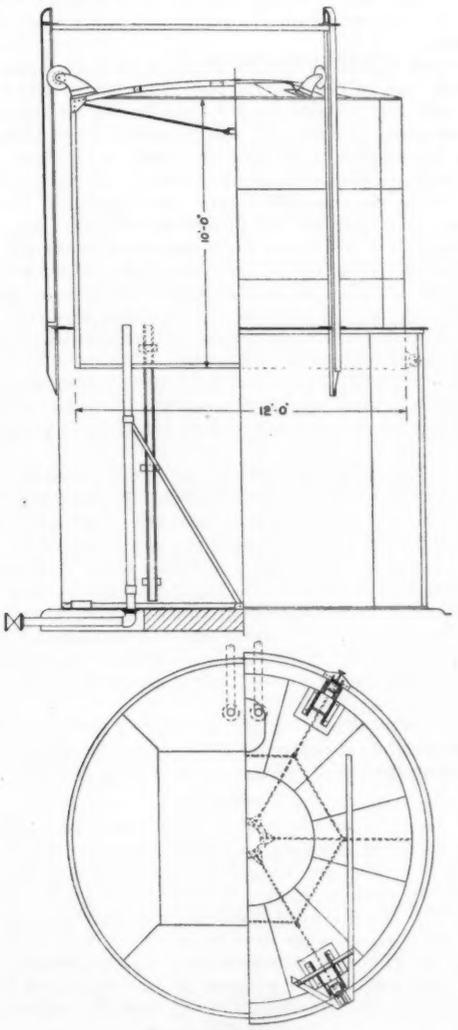


Fig. 16.—Gasholder.

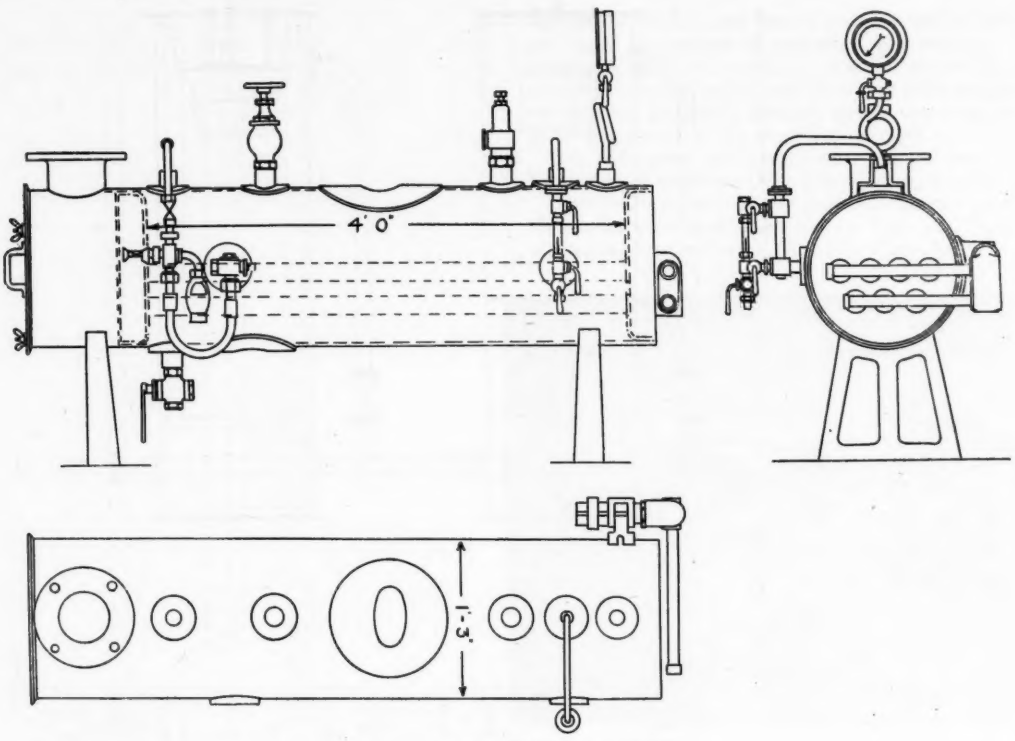


FIG. 17.—GAS FIRED BOILER.

responding with the main poise represents 25 lbs. and one division on the secondary scale represents 4 ozs. Each galvanized receptacle has a capacity of about 130 lbs. of coal, and since the machine responds to the nearest ¼-lb. the accuracy of the weighing is within 0·2 p.ct. The coke made is also weighed in similar receptacles on the same machine.

Tar and Liquor.—The amounts of tar and liquor, which separate out in the several pots situated between the retorts and the scrubbers, are transferred to covered galvanized tanks reserved for the purpose. Each tank, which has a total capacity of approximately 25 gallons, is provided with a drain cock at the bottom. After standing for some time, the tar and liquor are separated from one another and weighed in previously tared tanks. The amounts of tar and liquor are determined by weight, allowances being made for the known weights of water initially placed in the seal pot in the middle of the air condenser and in the pots in front of the horizontal retort setting. The volumes of tar and liquor are afterwards calculated from determined specific gravities.

Pitch.—In the case of the horizontal retort setting, the amounts of pitch removed from the crosses below the mouthpieces are collected and weighed at the end of the test.

Gas.—The make of purified gas is measured by the wet meter situated in the small laboratory adjoining the exhauster house. As a general practice readings, together with temperatures and pressures, are taken every hour; but on occasions readings are taken more frequently for the purpose of following the variations in the rates of gas evolution as carbonization proceeds. The meter is calibrated before and after each test. The make of purified gas as recorded by the meter is corrected for the amounts used for test purposes and taken at points prior to the meter.

Fuel to Heat Retorts.—The amount of fuel gas required to maintain the retorts at the desired temperatures is ascertained from periodic readings of the town-gas supply meter.

SAMPLING.

Coal and Coke.—The coal to be carbonized is sampled by placing a definite amount in a sample bin as each galvanized receptacle is filled for weighing. The amounts taken are then mixed, broken up into smaller pieces, and quartered down. The operations of crushing and quartering are continued until the sample has been reduced in amount to about 1 lb. The small sample is afterwards ground to a fine powder and used for the purpose of proximate and ultimate analyses and the determination of calorific values. The method of sampling the coke made is similar to that adopted for coal.

Tar and Liquor.—The tar and liquor, after separation from one another, are sampled from the 25-gallon tanks into which they are placed at the end of the test.

Pitch.—The quantities of pitch removed from the gas off-takes of the horizontal retorts are collected together, crushed, and quartered down. The operations of crushing and quartering are continued until the amount is reduced to about 1 lb.

Gas.—The outlet pipes of the two 1100 c.ft. holders are provided with plug cocks at positions K and L, Fig. 1, and with wheel valves at positions M and N. From a point between the plug cock K and the valve M of holder No. 1, a 1-in. gas service is taken and made to pass between the laboratory and the purifier, and thence to position P, where it is provided with a cock and a vertical pipe projecting about 4 ft. above ground level. A similar service from between L and N of holder No. 2 travels first behind the purifier and then to point Q. From both services branches are led into the laboratory. When holder No. 1 has been filled and the inlet and outlet valves have been closed, the holder is allowed to stand for several hours to enable the gas to become uniform in composition. The valve M and the cock P are then opened and gas is allowed to burn at the end of the vertical pipe at P. Meanwhile, calorific value and specific gravity determinations are made in the laboratory and samples are taken for purposes of analysis in an Orsat apparatus and in a Bone and Wheeler gas machine. The specific gravities are ordinarily determined in a Schilling's apparatus, and the calorific values in a Junker calorimeter as modified by the Birmingham Gas Department. The laboratory equipment also includes a Beasley recording calorimeter, which is used on occasions to record the calorific values of the gas leaving the holders. The method of examination of the gas from the second holder is similar to that described for the first holder.

The Beasley calorimeter is generally employed for the purpose of recording the calorific value of the gas made, as it travels from the purifier to the meter, a test service being run into the laboratory from the outlet of the purifier. Branches from this same service supply a Referee's sulphur apparatus, and provide the gas necessary for lead acetate paper tests.

The samples required for determinations of the amounts of sulphuretted hydrogen in the crude gas are taken from services connected to the gas main between the second scrubber and the purifier. These services are also used for long-period tests for naphthalene and ammonia.

Fuel to Heat Settings.—A branch service from the town gas meter to the laboratory enables tests to be made on the gas used to heat the retorts. Samples of the waste gases leaving the settings are drawn through silica tubes cemented into the brickwork at the bases of the chimneys.

MEASUREMENTS OF TEMPERATURES AND PRESSURES.

Horizontal Retorts.—The heating of the horizontal retorts is controlled by systematic measurements of the temperatures of the silica bricks situated above the burners. The silica bricks are sighted through the openings drilled in the inspection doors C, Fig. 3, and the temperatures are determined by means of a Cambridge optical pyrometer.

The temperatures of the charges at different points within the retorts are also taken on occasions. For this purpose four holes have been drilled and tapped in each of the self-sealing doors at the ends of the retorts. Iron tubes closed at one end are passed through these openings into the charges, and thermo-couples are placed in the tubes. The leads of the thermo-couples are insulated from one another by silica tubing. When the pyrometers are not in use, the holes in the retort doors are closed by metal plugs.

The temperatures of the air preheaters are measured by thermo-couples passed through the damper doors of the horizontal waste-gas flues. Pyrometers are also placed at positions D, Fig. 3, in the air mains between the preheaters and the burners.

The temperatures of the crude gas leaving the retorts are measured by thermo-couples placed in the top of the ascension pipes at points A of Fig. 4.

For the purpose of measuring the pressures at the top of the ascension pipes, connections are run from positions B (Fig. 4) to an inclined gauge so constructed that a movement of 1 in. represents $\frac{1}{10}$ in. water gauge.

Vertical Retorts.—The temperatures of the combustion chambers surrounding the vertical retorts may be determined by optical pyrometer sighted through the openings A of Fig. 7. These openings are ordinarily closed by conical brick plugs which can readily be removed. The temperatures of the products leaving the retorts may be measured by thermo-couples inserted in the gas off-takes.

Air Condensers, Scrubbers, &c.—The temperatures of the gas made are measured by mercury thermometers placed at the following points: (1) Inlet and outlet air condenser, (2) inlet and outlet exhauster, (3) inlet scrubber No. 1, (4) inlet scrubber No. 2, (5) inlet purifier, (6) inlet meter, and (7) outlet meter. The temperature of the air entering the compressor is also determined by a mercury thermometer.

Gas pressures are measured by means of a battery of vertical water gauges situated in the laboratory, to which connections are run from the following points: (1) inlet and outlet air condenser, (2) inlet scrubber No. 2, (3) inlet purifier, and (4) inlet meter. A vertical water gauge in the exhauster house registers the pressure at the outlet of the exhauster; and from a similar gauge outside the laboratory the pressure at the outlet of the meter may be measured. The pressure at the inlet exhauster is determined by an inclined gauge situated in the exhauster house, and the pressure at the outlet of the air compressor is registered by a mercury gauge.

HORIZONTAL SETTING, PRELIMINARY EXPERIMENTS.

TABLE I.—*Analyses of Coal Used. Percentages by Weight.*

Proximate Analysis (as Charged).		Ultimate Analysis (Dry Sample).	
Moisture	5·0	Ash	8·6
Volatile matter	33·0	Carbon	73·3
Fixed carbon	53·8	Hydrogen	4·8
Ash	8·2	Sulphur	2·3
		Nitrogen	1·7
		Oxygen	9·3
	100·0		100·0

Calorific value (gross) of dry coal, B.Th.U. per lb., 13,380.

When the retorts had been heated to about 500° C., they were filled with coke. The temperature of the setting was then slowly raised and every effort was made to obtain the maximum possible length of each retort at a uniform temperature. The maximum length which could be kept at a uniform temperature was about 4 ft., that is, within 1 ft. of the ends of the retorts. This maximum length was secured by heating the end combustion chambers to temperatures higher than those of the intermediate chambers, in order to allow for the losses of heat from the end walls of the setting. At temperatures of approximately 1100° C. the end combustion chambers were raised about 60° C. higher than the intermediate chambers.

When the desired temperature conditions of the retorts had been attained, the coke was discharged, and an iron stop was inserted in the discharge end of each retort. The iron stop consisted of a form of pusher with a circular plate of 10 in. diameter and a handle bent to rest on the end casting of the retort. The stop was held in position when the discharging door was closed. The handle was about 2 ft. 3 in. in length, so that the stop occupied a position about 9 in. from the outside wall of the setting. The iron stop was removed each time the retort was discharged.

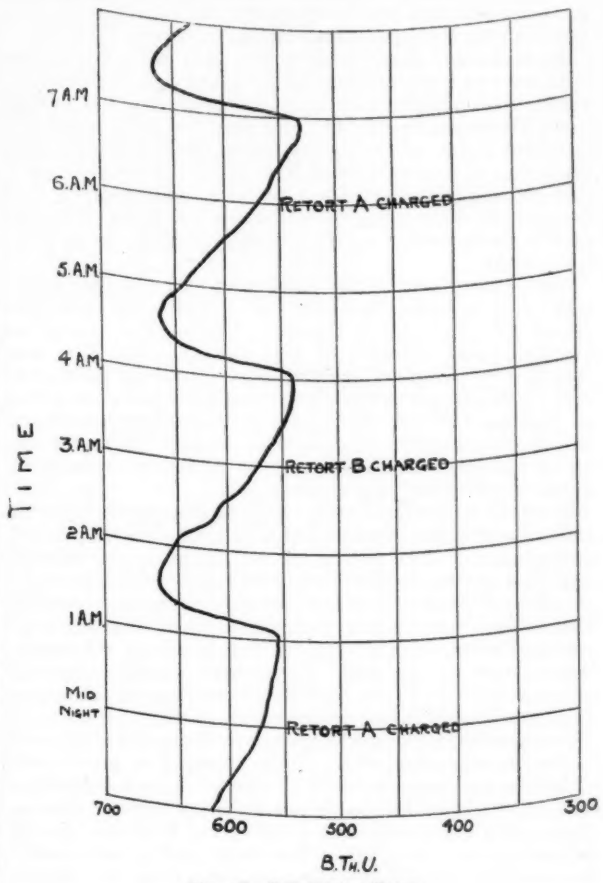


Fig. 18.—Calorimeter Chart.

The coal, which had previously been broken to the desired size (maximum about 2 in.), was charged by hand until it occupied the portion of the retort at a uniform temperature. During this operation the charge was rammed several times, and the coal was prevented from dropping into the gas off-take pipe by means of a piece of sheet metal

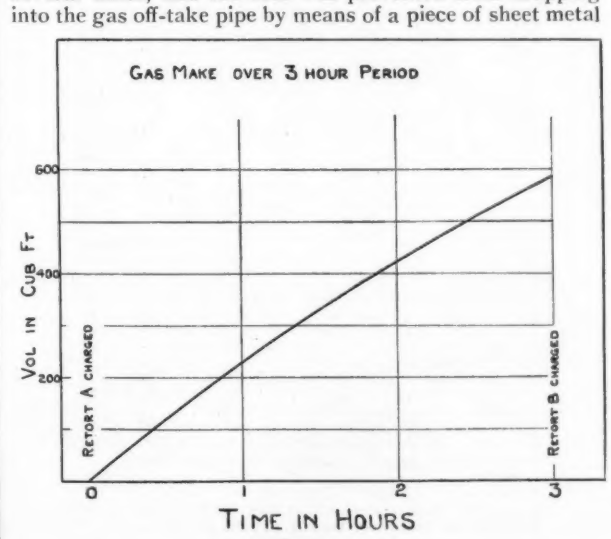


Fig. 19.

bent to fit the lower half of the retort mouthpiece. When the retort had been charged, the piece of sheet metal was removed and the door was closed.

The first trials were made with the object of determining the time required for carbonization with the combustion chambers at about 1150° C. Different charges were heated for periods varying from five to nine hours, and as a result it was concluded that the six-hour period produced a coke reasonably low in volatile matter. It was then decided to conduct trials in which the amounts of coal used and the products obtained were determined, and in which the proposed methods of operation could be tested.

Experimental Results.—The principal results obtained with the two horizontal retorts are given in Table II. Each retort was charged with approximately 124 lbs. of coal every six hours; and at the same time the pitch, which had collected in the off-take pipes below the mouthpiece, was removed. The operations of discharging, removal of pitch, and charging occupied from 10 to 15 minutes; the time occupied solely in charging was about 5 minutes. The two retorts, designated A and B, were charged alternately every three hours.

The amount of dry coke made was 13·3 cwt. per ton of coal, with a moisture content of 5 p.ct.; the coke contained 3·8 p.ct. volatile matter. The yield of gas of an average gross calorific of 603 B.Th.U. per c.ft. was 10,448 c.ft., which is equivalent to 63 therms per ton of coal. The amount of dry tar collected per ton of coal was 12 gallons, and the corresponding quantity of pitch removed from the gas off-takes was 16 lbs. The ammonia liquor recovered was equivalent to 23 lbs. of ammonium sulphate per ton of coal carbonized.

Since the horizontal setting contains only two retorts, the gas evolved varied greatly in quality during the progress of carbonization. The nature of the variations in calorific value is well brought out in Fig. 18, Plate 5, which is a copy of a typical portion of the chart taken from the recording calorimeter. This calorimeter was supplied with gas from a connection between the purifier and the meter. The variations shown by the chart are probably smaller than the actual variations in the quality of the gas as it passed through the foul main, owing to the mixing which must have occurred in the scrubbers and purifier. From Fig. 18 it may be seen that retort A was charged at about midnight; the door was closed at 12.14 a.m. As a result of the time required for the gas to reach the purifier and the lag of the calorimeter, the rich gas evolved from the charge did not commence to affect the chart until 1 a.m., when the recorded calorific value began to rise from a minimum of 555 B.Th.U. per c.ft. The calorific value then increased rapidly to a maximum of 670 B.Th.U. at 1.30 a.m., after which it fell more slowly to a minimum of 540 B.Th.U. at 4 a.m. At this point the rich gas first evolved from the new charge put into retort B at 3 a.m. had reached the calorimeter, with the result that the curve began to rise again.

TABLE II.—*Trial Test of Horizontal Retorts.*

Duration of test, hours	72
Coal carbonized, weight in lbs.	2,991
Coal carbonized per retort per day, lbs.	498
Duration of carbonization of each charge, hrs.	6
Weight of charge, average in lbs.	124
Coke (dry) made, cwts. per ton of coal	13·3
Volatile matter in coke, p.ct.	3·8
Gas per ton of coal, c.ft. at 60° Fahr. and 30 ins. saturated	10,448
Composition of gas, volume p.ct.:	
CO_2	2·6
C_mH_n	4·6
O_2	0·2
CO	10·8
H_2	46·7
CH_4	29·8
N_2	5·3
	100·0
Inerts (excluding oxygen), p.ct.	7·9
Calorific value of gas, B.Th.U. gross per c.ft.	603
" " " " net per c.ft.	543
Thermal value of gas, therms gross per ton coal	63·0
" " " " net per ton coal	56·7
Specific gravity of gas (air = 1)	0·46
Gas made per retort per day (60° Fahr. 30 ins. saturated), c.ft.	2325
Tar (dry), gallons per ton of coal	12·0
Ammoniacal liquor, gallons of 10 oz. per ton of coal	27·3
Ammonium sulphate (pure) equivalent per ton, lbs.	23·0
Sulphuretted hydrogen, grains per 100 c.ft. at inlet purifier	600
Sulphuretted hydrogen, volume p.ct.	1·0
Ammonia, grains per 100 c.ft. at inlet purifier	0·3
Naphthalene, grains per 100 c.ft. at inlet purifier	0·7
Sulphur in purified gas, grains per 100 c.ft.	20·6

The rate at which gas was given off during a three-hour period from the charging of retort A to the charging of retort B is shown by the curve, Fig. 19. In this curve the total volume of gas evolved is plotted against time for a typical period of three hours. During the first hour the volume of gas was 230 c.ft., and at the end of the second hour the volume had increased to 425 c.ft., so that the amount for the second hour was 195 c.ft. During the third hour the volume collected was 160 c.ft. The curve thus illustrates the reduction in the rate of gas evolution as carbonization proceeded.

The average temperatures of the combustion chambers, as measured by means of a Cambridge optical pyrometer, are given in Table III. The combustion chambers for each

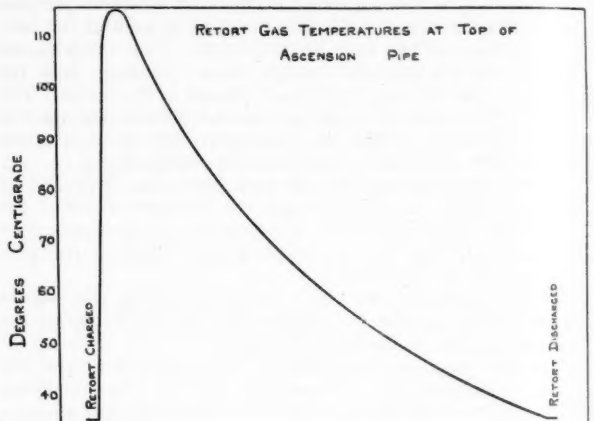


Fig. 20.

retort are numbered from the front or charging end to the discharging end of the setting. The temperatures of the end chambers, Nos. 1 and 6, averaged 1220° C., and the average of the middle chambers was 1150° C. The temperature of the air preheater in the horizontal waste-gas flues ranged between 700° and 800° C.

TABLE III.—*Temperatures of Retort Setting in Degrees Centigrade.*

Combustion Chamber.	Retort A.	Retort B.
No. 1	1210	1235
2	1137	1148
3	1157	1130
4	1153	1190
5	1168	1143
6	1215	1226

The averages of the temperatures and pressures of the gas and air as measured at different points of the plant are given in Table IV. The retorts were operated as nearly as possible at level gauge. The temperatures recorded at the outlet of the air condenser and at all succeeding points

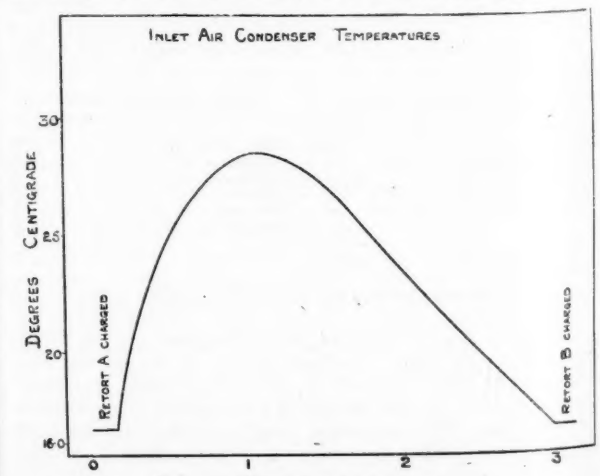


Fig. 21.

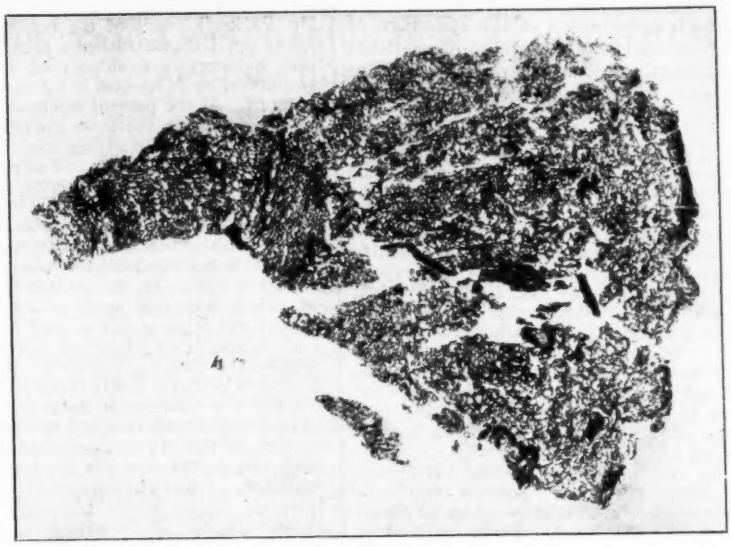


Fig. 22.

did not deviate greatly from the averages given in the table; and the variations which did occur were due mainly to changes in atmospheric conditions. The temperatures taken in the ascension pipes and at the inlet to the air condenser, however, varied as the carbonization of the charge in each retort progressed. Several series or readings, taken every five minutes during several hours, of the temperatures of the retort gases, as they travelled through the ascension pipes, were made. From these series, the curve given in Fig. 20 has been drawn by plotting temperatures in degrees Centigrade against time in hours. It may be seen from this curve that when the retort had been closed the temperature rose almost at once from 35° C. to a maximum of 115° C. The temperature then fell gradually until it again reached 35° C. at the end of the sixth hour, when the retort was due for discharging.

The temperatures of the gas at the inlet to the air condenser exhibited a three-hour cycle of changes, since the gases from both retorts passed this point of measurement and a charging operation took place every three hours. The nature of the temperature changes is shown in the curve, Fig. 21. When the first retort had been closed after being charged with coal, the temperature rose from 16·5° C. to a maximum of 28·5° C. at the end of one hour, after which there was a gradual diminution in temperature to a minimum of 16·5° C. when the second retort was opened for charging.

The temperature at the outlet of the air condenser averaged 6° C. (43° F.), so that the condenser is clearly of ample capacity.

TABLE IV.—*Temperatures and Pressures.*

Position of Measurement.	Temperature ° C.	Pressure. Inches Water.
Air to burners of retort A, position D, Fig. 3	210	..
Air to burners of retort B, position D, Fig. 3	290	..
Air compressor	12	27·9
Gas made—		
Ascension pipe, retort A, position A, Fig. 5	75	*Nil*
Ascension pipe, retort B, position A, Fig. 5	75	*Nil*
Air condenser, inlet	24	*Nil*
,, ,, outlet	6	*Nil*
Exhauster, inlet	13	−0·1
,, outlet	16	4·8
Scrubber No. 1, inlet	6	..
,, No. 2, inlet	6	4·8
Purifier, inlet	6	4·8
,, outlet	6	4·7
Meter, outlet	11	4·6

APPENDIX.

THE PREPARATION OF COKE SECTIONS.

The examination of a lump of coke with the object of determining its texture is normally a difficult matter, if it be desired to obtain an idea as to the size and shape of the pores, the wall thickness, and the general condition of the specimen. Micro-sections, as ordinarily examined by transmitted light, are usually much too small, and it is necessary to examine a number of sections to obtain information as to the structural differences existing in different parts of one piece of coke. For this reason, hand sections are also examined, but in these sections the shaded air pores do not show up well against the coke skeleton.

With these defects in mind, Dr. Rose, of the Koppers Company, has developed an ingenious method for revealing the structure of the coke, and for the details of the method we are indebted to Dr. E. W. Smith, of the Woodall-Duckham Companies. Essentially, the method consists in filling in the pores and cracks of a plane section with a suitable white cement and polishing the surface so obtained. The cement used is mainly plaster of paris with a proportion of admixed magnesia. The method has been tried by the Staff of the Research Committee for the preparation of sections of the coke made in the horizontal retorts of the experimental gas plant; and full-size photographs of two of the sections are reproduced in Figs. 22 and 23, Plate 6. From these photographs it may be seen that the cell walls of the coke are rendered easily visible against a strongly contrasting background, and that inert materials such as shale are clearly brought out.

Attention is drawn to this method of preparation of coke sections, since it is believed that it will prove valuable

Fig. 23.

in investigations in which comparison of the structure of coke made from different coals and by different methods is desirable. The preparation of micro-photographs of portions of the sections set in plaster of paris is at present in progress.

Prof. COBB, in introducing it, said: With reference to the Fourteenth Report, for convenience it is classified in that way as a report, but when you see it, you will notice that it is really rather a record interesting, we believe, to the Institution of Gas Engineers than an actual report upon the detail of scientific work. It consists essentially of a description of the experimental plant erected by the kindness of Mr. Henry Woodall, with some friends who wished to be associated with him, at the University of Leeds, as a memorial to his father, the late Sir Corbet Woodall; the description to serve as a record in the "Transactions" of the Institution of Gas Engineers of this valuable addition to the equipment of the Department of Coal Gas and Fuel Industries of the University. During the year Dr. Parker has been engaged in trying-out different portions of the plant, and making such adjustments in it as were necessary to fit it for use not only for demonstration purposes, but for the solution of the specific problems of the gas industry. As always happens in the case of a new plant of this sort—which of necessity departs in so many respects from standard practice in order to meet special needs—the time and labour required in getting it into operation have been considerable, in spite of the care bestowed upon it by its skilled and experienced designers. The Committee are greatly indebted to Dr. Parker for the work that he has been expending upon it, and hope to begin gathering the harvest in the near future.

Dr. A. PARKER said: In September, 1917, Mr. Henry Woodall made the generous offer to erect and present to the University of Leeds an experimental plant in memory of his father, the late Sir Corbet Woodall. This offer was gratefully accepted; but the conditions prevailing at that time prevented the carrying out of the project. When circumstances became more favourable, Mr. Henry Woodall commenced operations, and the plant was officially presented to the University at the opening ceremony held on March 26 last year.

The original idea that the memorial might take the form of an experimental plant was due to Mr. W. T. Dunn. In the first instance, the suggestion was to erect one setting of retorts; but so many friends of the late Sir Corbet Woodall expressed a desire to help, that the scheme grew until finally two settings, including both horizontal and vertical retorts, were installed. Mr. J. F. Scott, after consultation with Prof. Cobb, designed the general lay-out of the installation to meet the requirements of the site available and the units proposed.

The first utilization of the plant has been made by the Gas Investigation Committee. We commenced operations last year, when the work on the waste-heat boilers attached to the vertical retort settings at Windsor Street, Birmingham, had been completed. In the first place the many smaller fittings necessary in an installation intended not only for demonstration purposes, but also for the investigation of definite problems, were added. Gas making and carbonization trials on the horizontal retorts were then carried out; and at the same time the performance of the condensing, scrubbing, purifying apparatus, &c., was examined.

It must be emphasized that the installation is not in any way a small-scale model of a gas-works, but contains many features which differ from usual practice. It was therefore necessary that preliminary trials should be conducted before a definite research programme could be commenced. The preliminary trials of the horizontal setting and of the condensing and purifying apparatus, &c., have been completed; and certain alterations have been made. As a result of these tests and alterations, the suitability of the horizontal setting and auxiliary plant as a carbonization unit has been established. Tests of the vertical retort setting are now practically complete, and it is hoped we shall be able to embark on a definite research programme almost immediately.

The Fourteenth Report is a description of the experimental plant as it now stands; and, as Prof. Cobb has already stated, the description is given at this stage to serve as a record in the Transactions of the Institution of Gas Engineers.

As an appendix to the report a brief description is given of a method of preparation of coke sections as devised by Dr. Rose, of America, and brought to our notice by Dr. E. W. Smith. Attention is drawn to this method, since it is believed that it will prove useful in investigations in which comparison of the structure of coke made from different coals and by different methods is desirable. One section prepared as described has been brought along for inspection by those members who may be interested.

Mr. THOMAS GLOVER (Norwich): I do not wish to detain the meeting, but, as a member of the Investigation Committee who has taken an interest in this investigation from the earliest days, I am bound to say that I feel a little puzzled as to the definite research programme which we have in view at the present time. I hope that any members, outside the Investigation Committee, who have ideas will be kind enough to communicate them to us for our guidance and for our investigation. Dr. Parker's précis of the report on the investigation of coke opens up, I think, rather a promising field. Coke at the present moment is a subject of very great importance to gas engineers, as at its best it forms such a large credit to the coal account. At the present moment we are face to face with considerable competition from the coke-oven people, who are grading their coke and entering into competition with gas coke, and are upsetting our market. I think we cannot do amiss by pursuing this investigation on coke, especially if it can be directed through practical channels which will help the industry to market its coke—after having produced the right type—and keep up the price as much as possible, and so keep up that credit to the coal account which has been so important in the past. I understand from an old student of the Institution who has been out doing important work in connection with vertical retorts in Boston and other places in the United States that this investigation on coke is an important matter at the Technical College in Boston, and that it is not always the best thing to place the coke in plaster of Paris. It is better to investigate the cavities in the coke by some addition to the microscope which helps to show-up the grain and structure and texture of the coke better than can be seen by the microscope alone or by the naked eye. All the same, we are interested in the specimens which Dr. Parker has exhibited. I had the curiosity to send Prof. Cobb some pieces from my works which I thought were better than those he showed me on the Investigation Committee. I do not know what is the position yet with regard to those samples, but I shall be glad to see them when they are ready for demonstration. Again, I would reiterate that the Committee would like ideas from the members of the Institution for the future work of this Investigation Committee.

Dr. R. LESSING: The last remark on coke by Mr. Glover encourages me to remind the members of the Institution that a similar method of dealing with coke samples was incorporated in a paper which I had the privilege of reading before the Institution thirteen years ago. An almost identical method for showing-up the structure of coke was then used; the only difference being that I employed then, and still do, wax of high melting-point to obtain the same effect. While specimens so prepared might not look so effective from a distance as the plaster of Paris ones do, they have the advantage that the wax can be easily removed by melting. Then we know the composition, and can study the coke under the microscope or by any other means, and analyze it as before. The specimens prepared in connection with my paper thirteen years ago were shown in some very fine photographs which are incorporated in the Transactions for that year. I should like to emphasize the point made by Mr. Glover that the study of the coke, and, obviously, of the processes by which the coke is made, and incidentally some gas, is of the greatest possible importance, and may actually mean a turning-point in our methods of carbonizing—at any rate in the methods of preparing the coal for carbonization. I have not the slightest doubt that these investigations will lead to results which will involve vital alterations in the processes to which we have hitherto been accustomed.

The PRESIDENT: I understand that there is shortly to be a meeting of the Investigation Committee; and I am certain that the Committee will be only too pleased to receive suggestions from any member of the Institution bearing on the work in view. I will ask Prof. Cobb to say a word.

Prof. COBB: I can only endorse all that Mr. Glover has said. The Committee are always willing to receive suggestions as to what lines of investigation are best calculated to develop the gas industry, and also on the subject of carbonization, which is the basis of the gas industry. I also endorse what Mr. Glover said about studying the structure of the coke. This is a suggestion which presents itself as being particularly suitable for our investigations, and it is one with which I entirely agree. As Mr. Glover knows, this is a subject which is coming up for discussion in more detail by the Investigation Committee tomorrow. Dr. Lessing's remarks confirm the importance of the subject, if any confirmation were needed. He also put forward, I will not say a claim, but something in the nature of a claim to have anticipated this method of preparation. Of course, Dr. Lessing knows perfectly well that not only with coke, but with other things, the impregnation of a porous substance with wax and other media for filling-up the pores is not a thing upon which one could take out a valid patent at the present day. It is simply that this method is very convenient, and it does give—as some of you may be interested in seeing, if you have not already seen it—a very vivid contrast, and makes a striking demonstration to the eye of the structure of a coke. I think you may be interested in seeing it, and I think this method, or this method modified as we may find necessary for the investigation of the finer pores, and so on, will prove exceedingly useful not only in our investigations, but in the investigations which may be undertaken by other members of the Institution. It was for this reason that, without being able to claim anything in the way of originality in connection with it—because it was brought to our notice by Dr. Smith—we thought it advisable to show one or two of these prepared specimens. I beg to move the adoption of the report.

The PRESIDENT: I have very great pleasure in seconding the motion.

The report was adopted.

NOTES ON THE TANKLESS GASHOLDER AT THE ETABLISSEMENTS ARBEL, DOUAI, FRANCE.

By L. ROLLAND d'ESTAPE, Ingénieur E.C.P.,
President of the Société Technique de l'Industrie du Gaz en France, and Hon. Member of the Institution of Gas Engineers.

The idea of eliminating from gasholder design the tank and the large volume of water contained therein, and substituting for them simply a vertical cylinder having a fixed base and an upper platform rising and falling in the cylinder, is not new. The difficulty of devising a gas-tight form of packing, either dry or wet, between the cylinder and the moving platform, had for long been the sole obstacle in the way of gasholder builders, until the problem was first solved in Germany, notably by the Maschinenfabrik Augsburg-Nürnberg, who have constructed a number of these tankless holders up to a capacity of 120,000 c.m. (nearly 4¼ million c.ft.).

The tankless gasholder at the Arbel Works at Douai, which is described in the present paper, was the first of its type built in France.* Work was commenced on it in 1922 by the Bonnet-Spazin Company, who are the licensees of the Augsburg-Nürnberg patent; and it was put into commission in 1923. The capacity of the holder is 27,500 c.m. (970,000 c.ft.), which could be increased on existing lines to 40,000 c.m. (1,412,600 c.ft.). Recently Messrs. Bonnet-Spazin have installed, for the Société du Gaz de Paris, three tankless holders of a capacity of 2000 and 3000 c.m. (70,630 and 105,945 c.ft.). They have also in course of construction the following holders: Sartrouville (15,000 c.m., 529,725 c.ft); St. Etienne Colliery Company (20,000 c.m., 706,300 c.ft.); and Bordeaux (30,000 c.m., 1,059,450 c.ft.).

The main features of the Arbel holder, which is illustrated in the plate appended, are as follows:

1.—An outer shell in the form of an upright 26-sided polygon anchored to a fixed base of 3 mm. (⅛ in.) plate on the ground. Two inlet and two outlet pipes M for the gas, all of them 500 mm. diameter (19·7 in.), are fixed to the base-plate.

2.—A movable roller-guided disc A, rising or falling under the pressure of the gas, like a piston, inside the shell.

3.—A roof over all.

The following are some leading dimensions of the structure:

Height from base-plate to eave of roof	36 m.	(118 ft.).
Diameter of circumscribed circle ...	34 m.	(111 ft.).
" Stroke " of disc	30·875 m.	(101 ft.).
Weight of disc	90 t.*	(88·5 tons).
Pressure thrown, W.G.	100 mm.	(3·9 in.).

(* t. = metric tons.)

The shell, the base-plate, and the roof form a rigid structure and offer the maximum resistance to the wind; while the moving disc functions under cover in an absolutely still atmosphere.

The most difficult problem is how to obtain gas-tightness between the periphery of the moving disc and the holder. The rubbing surface must not be dry, for then metal-on-metal friction would have to be contended with. The periphery of the disc is, therefore, fluid-sealed, and the liquid used is tar. Further, in order to ensure that the disc shall rise and fall smoothly, it is obvious that the inner surface of the 26-sided polygonal holder must be absolutely smooth; anything in the nature of a projecting rivet-head is, of course, out of the question. For this reason the holder has been developed in the shape of a polygon. As shown in the illustration, for each division of the holder there is a rigid mounting, shaped to fit the angle formed by adjacent sides of the structure. These angle-pieces join the base to the roof, act as guide-rails for the rollers B, and serve to connect the plates of the shell. These latter are 4 mm. (5/32 in.) in thickness, and are strengthened by outwardly flanging the edges, and fitting channel irons thereto. The plates thus strengthened retain a plane surface; while the method of construction enables all rivets to be exterior, thus preserving the smooth interior face of the shell.

There is nothing particularly noteworthy about the roof; it steadies the upper part of the holder, and constitutes with the latter and the base-plate a statically stable structure. In addition it prevents rain and snow from falling on and affecting the disc. A window O admits light into the interior of the holder, and a gallery Q and ladder P facilitate descent on to the top of the disc itself, whatever its height may be. The ladder is a double one, articulated, and conseqently absolutely secure.

The disc or piston A is built up of sheets, and is strengthened with trusses C. In its movement it is guided by as many pairs of radial rollers B as there are angles in the shell. Tangential guide-rollers are unnecessary, in view of the absence of wind-pressure effects. Round the periphery of the disc is the special gas-tight device which is composed of: (1) An annulus K full of tar (see enlarged view); (2) a series of counterbalanced levers which maintain pressure against fitted metal blocks immersed in the tar, and which adjust themselves automatically; and (3) a canvas bearing-piece, one edge of which is fixed to the disc and the other gripped between the blocks and the weighted levers. It will therefore be understood that there is no friction on the bearing-piece, which merely serves to support, over a width of a few centimetres, the weight of the column of tar.

Generally speaking, the depth of tar should substantially balance double the maximum pressure it is possible to obtain from the holder by heavily loading the piston. At the Arbel Works the pressure normally thrown by the piston is 100 mm.; but this can be raised to 300 mm. by loading the disc with concrete blocks weighing 180 t. (177 tons). The depth of tar in the annulus is therefore 626 mm. (25 in.).

The sealing ring does not actually touch the shell, and there is no contact of metal on metal, for there is always a gentle percolation of tar between them. The sliding of the seal blocks upon the shell can give rise to no wear and tear, since the sheeting and the blocks are continually being washed over by the tar; and the friction is absorbed not directly by the metal surfaces, but by the thin film of tar which they enclose. Thus, as the disc rises and falls, the annulus of tar acts as a brush, continually painting the internal surface of the holder.

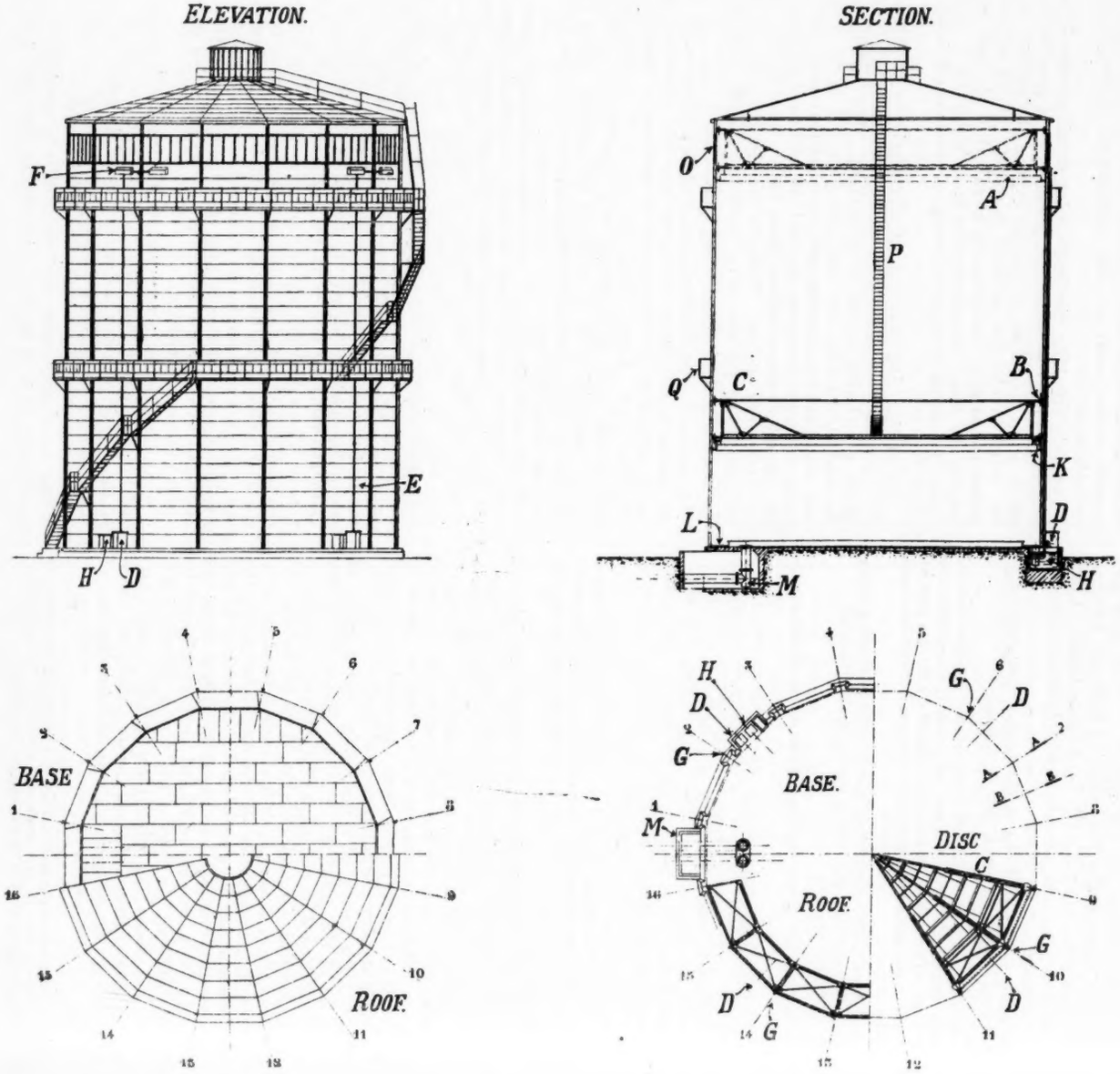
A descent on to the disc gives immediate assurance of the perfect gas-tightness of the device. Not a bubble can be discovered on the surface of the tar, nor is there the slightest smell. Even without any tar at all the movable disc is sufficiently tight around its circumference to allow during the building of the holder of the gradual raising of the disc by air pressure from a blower; the disc being used as a working platform.

A very small quantity of tar is thus continuously percolating between the disc and the shell; and, flowing down the sides, is collected in an interior annular channel L surrounding the base-plate. Thence it passes through cast-iron pipes into external reservoirs. As the level rises or falls in the latter, floats respectively start or stop small electrically-driven pumps D which raise the tar through the pipe E to a further series of reservoirs F near the top of the holder, whence it flows down the walls to the tar well H of the disc itself. This well is divided at G into as many sectors as there are pumps—eight in the case of the Arbel holder. These divisions are necessary in order to maintain the proper depth of tar in the well, even in the event of the disc taking a tilt from the horizontal. For each division, however, a stand-by pump is provided to ensure the continued supply of tar in case of a breakdown. If too much tar is forced into one sector, the neighbouring ones are fed through overflows.

A 1½ h.p. electric motor suffices to drive each pump; and the duration of run varies according to the viscosity of the tar—in summer not more than eight minutes per hour, in winter once in twelve or even twenty-four hours. The consumption of energy is thus infinitesimal.

The most satisfactory seal to employ is specially prepared tar. It is to be remembered that the same tar is

* Visited by members of the Société Technique du Gaz and the Institution of Gas Engineers on June 29, 1924, during the celebrations of the Jubilee of the Société and the centenary of the gas industry in France.


ELEVATION.
F
E
H
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SECTION.
O
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P
Q
C
B
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BASE
ROOF.
BASE.
ROOF.
DISC
C
G
D
M
DISC AT UPPER LIMIT.
C
B
A
SECTION A.A.
SECTION B.B.
K
N
References.
A. Disc.
B. Guide Rollers.
C. Disc Framing.
D. Motor and Pump.
E. Tar Uptake Pipe.
F. Tar Distributor.
G. Tar Partition in Annulus.
H. Tar Well.
K. Annulus.
L. Tar Channel.
M. Gas Inlet and Outlet.
N. Safety Gas Outlet.
O. Window.
P. Ladder.
Q. Gallery.

circulated over and over again. The essential qualities to ensure are constancy of composition and a certain degree of viscosity at low temperatures. Light oils that might volatilize must, therefore, be eliminated from it. The method of preparation is to maintain the mixture at 60° C. for three hours with aeration. On cooling to 15° or 20° below zero, it must remain sufficiently fluid for an ordinary glass rod (as used in the laboratory) to sink by its own weight, and even submerge itself sideways to some extent.

As a precautionary measure, if gas continues to enter the holder when the disc is at the top of its travel, safety outlets N are provided which are uncovered when the disc reaches its limiting position; and gas escapes into the open air—an arrangement involving no danger, inasmuch as the outlet is at the highest point of the structure.

Tankless gasholders present the following advantages over those of other types: The necessity for warming the tank and the cups is removed; and the possibility of accidents from ice during unexpectedly cold weather or through carelessness during a frosty spell is avoided. Further, there is the saving of the cost of installing the boiler and pipes, and of that of maintenance and running charges.

In telescopic holders, pressures varying from 100 to 300 mm. (3·9 to 11·7 in.) are thrown (the inconvenience of this need not be laboured), while in tankless holders the pressure is constant, for it depends only on the weight of the movable disc as modified by the upward pressure of the gas. If working proves the advisability of so doing, the holder pressure can be increased simply by placing concrete blocks on the disc, without in any way interfering with the working. It has already been pointed out that in the case of the holder at the Arbel Works, the pressure can easily be varied between 100 and 300 mm. (w.g.).

As regards rigidity and resistance to the wind, the stability of the tankless structure is greatly superior to that of the column-guided holder. The disc moves in a closed box and a still atmosphere unexposed to gusts of wind. Columns, on the other hand, can be neither completely rigid nor absolutely vertical, and the lifts of the telescopic holder are subject to violent wind stresses.

Paint, which is an indispensable factor in the upkeep of tanks and lifts, in the case of the tankless holder need only be applied to the exterior of the shell. In other types of holder the interior of the tank, the lifts, and cups can only be painted when the water has been run out; and the metal oxidizes more quickly through being alternately in water and air.

It is impossible to inspect the greater part of the telescopic holder; and during every repair to tank or lifts, anything which falls into and deranges a cup entails draining the tank. In the tankless system the exterior of the holder is always available for painting, while the interior is continually being treated with a coating of tar from the disc annulus. If it is desired to increase the capacity, it is done simply by adding height to the shell, without in any other way encroaching upon the holder. This, however, is a fairly delicate operation, for which it is necessary to take the holder out of commission. As mentioned early in the paper, the Arbel holder has a present capacity of 27,500 cm. (970,000 c.ft.), which could be increased to 40,000 cm. (1,412,600 c.ft.).

In building a "wet" holder, in order to attain the required solidity, it is necessary to carry out much excavation and lay heavy foundations over the whole required area of ground. Settlements are by no means rare under the mass of water; tanks are apt to lose their shape or to crack; and repairs are difficult and costly. In the case of tankless holders, however, strong foundations are only necessary beneath the foundation ring of the shell; and here an earth resistance of about 1 kg. per sq.cm. (15 lbs. per sq.in.) usually suffices. Inside the ring, thin concrete is sufficient; and in the case of the Arbel holder there is only a bed of clinker concrete 10 cm. (3·9 in.) thick beneath the base-plate. Under the foundation ring of the shell there is broken-brick concrete 3 m. (9·8 ft.) deep and 30 cm. (11·8 in.) thick on a base 1·60 m. (5·2 ft.) wide by 23 cm. (9 in.) high. The total pressure carried by the earth below the foundations, including an allowance for wind stresses, is 1·130 kg. per sq.cm. (16·5 lbs. per sq.in.); and if the weight of the foundations themselves is omitted, it amounts to only 0·692 kg. per sq.cm. (10·1 lbs. per sq.in.).

Against these advantages, the only inconvenience that can be set is possible irregularity in the working of the tar pumps, and their running costs. But it has already been explained that, owing to the arrangement of partitioning the wells and fitting them with weirs, several pumps can be out of action without the slightest danger arising; and, as for the consumption of energy, this is insignificant. The Etablissements Arbel are absolutely satisfied with the regular working of their holder.

As to financial considerations, it may be stated that, up to a capacity of 10,000 cm. (353,148 c.ft.), the cost of a tankless gasholder is substantially the same as that of a holder with tank. Above 10,000 cm. the tankless type of holder shows an economy in construction of 5 to 20 p.ct. in its favour, according to the dimensions. That there is not a greater saving is explained by the fact that, while the amount of metal needed is very considerably reduced, the necessarily precise plating work called for by the tankless design is costly.

Discussion.

The PRESIDENT: We have here a very interesting and valuable paper on the tankless gasholder. A number of the members saw the holder at Douai when we were in France, and were much interested. I was so much interested that I have been over to Paris to see one of the holders there at work and one under construction, and I venture to think that it will not be long before some of the municipalities and companies erect these holders in this country. There is no doubt that, though the ordinary telescopic gasholder with water, and a brick or steel tank, has served us well, there is a great deal to be said for the tankless design. One of the most important things is that, if we have tankless holders, we shall be able to supply dry gas, and that would be an important matter where gas is distributed over large areas. The tankless gasholder has passed beyond the stage of experimental work, and is now a practical reality. The author of the paper has told us that the tank at Douai is capable of being increased to a capacity of 1½ million c.ft. I believe in America an order has been placed for a tank of a capacity of 4½ million c.ft., and that on the Continent orders have been placed for very large ones. One of the largest and most prominent American gas engineers has informed me that, so far as his Company and those he represents are concerned, he should recommend in the future that they use tankless holders. I shall now be very glad to have comments upon the paper, and especially from those who have had practical experience in this construction of gasholders. At the same time I am sure I am expressing your opinion when I say that we feel very much indebted to the French Society for presenting us with this paper.

Mr. J. P. LEATHER: I think we must echo what the President has said in thanking our French friends for giving us this paper. With regard to the tankless gasholder, I need not go into the question of the advantages mentioned in the paper; but there occur to me one or two disadvantages. I will first name one which is not very substantial—that the holder is always up. A holder is always rather an eyesore, and we are sometimes found fault with for having huge ones projecting into the sky and obliterating the view. At any rate I have had that experience, because there has been rather strong condemnation of a holder I recently erected, on the ground that it prevents people having a view of the country. These tankless holders will always be up, and you will not be able to see between the piers. Another question that has occurred to me is that, after all, the wind must have a considerable effect on these structures. To begin with, the plates between the supports are flat, and a strong wind will certainly tend to bend them slightly inwards. Further than that, unless there is a fairly strong framing, the framing will yield just as much as the framing of an ordinary column gasholder. I know the question of the yield of the framing of the latter is treated differently in some Continental works from what we have been inclined to do in England. Certainly my own practice has been to make a fairly strong framing; but on some works on the Continent the framing does not seem to be made of anything like such large-section columns as we have here. With the tankless holder you have the pressure of the wind on the tank or on whatever you call the structure, just as much as you have in an ordinary holder; and when you have a strong wind, it must have some effect. And as the disc is naturally very rigid, there must be a tendency to alter the space between the disc and the tank at certain points. I do not know whether our friend who has read the paper can tell us anything as to the experience in this respect—whether anyone has been on the disc when there has been a strong wind, and seen what the effect is.

M. BARIL, who replied in French, said that in countries where the wind is very strong means are taken to make the holder more rigid by strengthening the flanges and sheets. The wind in some parts of the Continent is not so strong as in England, and it is not necessary to construct so rigidly as would be the case in this country. Where gales are usual, the diameter of the holder is increased.

Mr. R. J. MILBOURNE: I appreciate very much the paper

which has been read, giving a description of the gasholder which most of you saw when the Institution visited France last year. I have had the pleasure and the privilege of seeing not only that holder, but a number of others of the tankless type which have been at work for a considerable time; and on each occasion my mission was undoubtedly to find out the defects of this particular system, because, as no doubt you are aware, I am interested in a Company which has taken up the patent rights for Great Britain. I must say that we have never been able yet to find a gas engineer who is working these tankless gasholders to say that there is any disadvantage whatever; on the contrary, they all say that there is undoubtedly a great advantage by adopting this particular system. One of the principal considerations which, it appears to me, commends this design to the notice of the English gas engineer is that it prevents the corrosion of sheets, such as we have in an ordinary water gasholder. The exterior is very easily painted and very "get-at-able" from the platforms which, I think I might mention in answer to Mr. Leather, not only serve the purpose of giving easy access to the exterior of the holder, but are added in accordance with calculations to give the necessary strength to the whole of the structure. As to the point of wind pressure—undoubtedly there is a continual pressure on the surface of a tankless gasholder; but the type is in a much better shape and form to withstand the wind pressure than is an ordinary guide-framed or spiral holder. Another consideration which is well worth notice is the interior of the structure; from my experience, during the past few years at all events, due no doubt to the present methods of carbonization and probably purification, there is a greater tendency for the ordinary gasholder to corrode from the inside. Until 15 years ago it was my experience that the inside of a holder was as pure and as safe from corrosion as could be desired at any time, and that the action of the gas which was then made—I suppose you would call it "straight" gas—caused no inconvenience from any corrosion on the inside sheets. It has, however, recently been my experience that corrosion does take place from the inside; and I have had the opportunity of talking over this particular point with a very eminent gas engineer who visited England last year, who informed me that they found in the Colonies that this particular difficulty is causing them great concern. If that is so, the tankless gasholder undoubtedly offers a very excellent design for the prevention of internal corrosion, as the inside is continually coated with tar, and therefore corrosion cannot take place. The other little difficulty which might naturally at first sight appear, is the question of the working of the pumps; but as the writer of this paper has pointed out, there are a number of pumps, and at the time the holder is being erected the disc is practically tight without any seal of tar being added. At the time I first visited the holder at Douai, during erection, the disc was up—I should think within about 10 ft. of the top—but there was no apparent leakage, so that it does not seem to me from the experience I have had that the danger of leakage with these particular holders is very great. I do recognize, however, that the English gas engineer is particularly conservative, and will no doubt need to have an actual example in this country under test before this particular type of holder makes much headway. Of course in England this particular type of gasholder will have a very serious competitor, as regards the cost of the holder, in having to compete with the spiral holder; and I should think the economical size would be much above what the writer of this paper says is the case on the Continent. They do not on the Continent, for some reason which is best known to themselves, adopt the spiral holder; and it is only in England that we use that particular type of construction to any great extent. I do not know that I can add any further useful remarks; but Mr. Gill, who is present, has had the advantage of seeing the particular type which is being erected by the Americans, and no doubt he will be able to tell us something about them which will interest us.

Mr. G. M. GILL: I have really very little to say about the tankless gasholder, but there is one matter which might possibly interest you. When I was recently in America, the builder of the tankless gasholders there told me that he had orders for an aggregate capacity of 65 million c.ft., and included in that were two or three tanks of 15 million c.ft. capacity each. This, I think, shows you the way the American gas engineers at any rate are looking at this problem. Mr. Milbourne mentioned that this was the only country where the spiral holder has made any headway. In America there seemed to be hardly any—I think I did see a small one somewhere, but they have not taken up that design at all. I notice the old type of gasholder has been referred to as the "wet" holder. It may be that if the new type is the "dry" gasholder, that may be a reason why the American gas engineer has shown a tendency to adopt it. (Loud laughter.)

M. BARIL then gave the following supplementary remarks. The Société d'Eclairage, Chauffage, et Force Motrice, who supply the suburbs of Paris, also have a tankless holder of 6000 cub.m. capacity, which was successfully put into commission some weeks ago. This holder was ordered as the result of a visit by M. Bazille, Chief Engineer at the Gennevilliers Works, to holders of the same type in Mügeln (1000 cub.m.), Waldenbourg (27,000 cub.m.), and Staaken (60,000 cub.m.). The economy realized by us by installing this tankless holder is not great, but it was selected owing to the small space occupied—the diameter of a circumscribing circle is 19.5 m., while that of an ordinary one-lift holder of the same capacity would be 30 m. The "E.C.F.M." Company are very interested in these holders, and we wish to enlarge on the following features: (*a*) Means of access to the piston. In the improbable, but possible, event of a man being overcome by gas when inside the holder, the collapsible ladder, easy enough for an able-bodied man to negotiate, would present great difficulty to one burdened with an unconscious comrade; and to overcome this difficulty, manholes have in some instances been fitted to the shell at various points of the piston travel. (*b*) Tar for the joints. It is very difficult, if not impossible, to find a material exactly answering the specification of the builders. At Gennevilliers a mixture of dehydrated tar, 75 p.ct., and anthracene oil, 25 p.ct., is employed; but it will probably be necessary to increase the quantity of oil in the winter. (*c*) Pumps. In the event of a sudden drop in the temperature, it is probable that the pumps will labour in starting up, owing to the greater viscosity of the tar; they may even refuse to start, if driven by high-speed motors. The exposed piping, therefore, should be lagged. Further, as there is a danger of the electric circuit fusing, it may be advisable to start up the pumps by hand, and a safeguard is to run groups of pumps in parallel. Another danger lies in the possibility of the public electricity supply failing; and it is as well to have a private stand-by generating plant. As a final protection, a small tar tank sheltered from the cold may be placed under the roof of the holder.

Mr. FRANK PRENTICE (Ipswich): I should like to ask why such a large number of pumps are required to fill the tar receptacles. Is it not continuous all the way round, or are there a number of separate tar receptacles to be sealed, and therefore a large number of pumps required? It would be interesting to have a reply to this.

M. BARIL explained that several pumps are installed owing to the tar ring being partitioned. Otherwise there would be a risk of the tar flowing to one side and putting the structure out of level. He added, however, that, not being a constructor of these tanks, he was not able to discuss the small points of detail in design.

Mr. GEORGE C. PEARSON (Birmingham): I would like to ask if any troubles have arisen in connection with the canvas bearing-piece. It appears from an examination of the design that there is a canvas-bearing piece which holds the tar against the sides of the tank, and that the action of the piston rising and falling would rub it against the sides of the tank. If this canvas gave way, it might be a serious matter; and it might be very difficult to replace it.

Mr. JOHN FOSTER (Birmingham): Supposing you get a holder working up and down three and four times a day, as we do in Birmingham, what effect would that have on the top seal?

The PRESIDENT: In reply to the last speaker, when I was in Paris, the holder was rising and falling very intermittently, and was used very much more than an ordinary holder. I was told by the engineers there that they had no trouble whatever, and such working is, of course, a very much more severe test in the case of the tankless than in the case of the ordinary holder. I may say that there will be a model of the tankless holder at the Litchurch Works at Derby on Friday, and the members will be able to see it. I have arranged with Mr. Milbourne to be there, and he will be very pleased to answer any questions that may be put to him.

Mr. CHARLES F. BOTLEY (Hastings): I am sure we all appreciate the fact that our friend from France has addressed us in our own language in reading this paper—a task which some of us would not like to essay in the opposite direction. He has also given his replies in his own beautiful language, and we have had our friend M. Zollikofer to interpret them for us. I should like to have added a remark or two; but as we are going to view a model, perhaps my questions will be answered then. At the same time I must express my disappointment that this design of tankless holder cannot be produced more economically. It seems to me a great pity that something of this kind is not available at a lower cost. Also might I venture to say that there may be other reasons for the corrosion of gasholders than that due to the kind of gas which is now manufactured. I think there are several with which most of us are acquainted. We are greatly indebted to our friend, and I have great pleasure in moving that we give him a hearty vote of thanks not only for the information, but also for being so good as to address us in our own language.

Mr. SAMUEL TAGG (Preston): I regard this valuable paper as a graceful extension of the kindly facilities which the French engineers offered us last year. I am sure we are very grateful both for the paper and to M. Baril for his services in reading it to us in the absence of the author. I have much pleasure in seconding the vote of thanks.

The PRESIDENT: I am sure it requires no words of mine to emphasize the vote that has been proposed and seconded. We all have very pleasant recollections of our visit to France, and we are delighted that some of our French confrères are at the meeting to-day.

The vote of thanks was carried with acclamation; and M. Baril briefly expressed his appreciation of the manner in which the paper had been received.

SELECTION, DESIGN, AND CONSTRUCTION OF NEW CARBONIZING PLANT AT STRETFORD.

By W. M. CARR, of Stretford.

The question of the selection of carbonizing plant is a problem which has become increasingly difficult during the last few years, owing to the great fluctuation in the relative values of coal and residual products. It is a problem with many varying aspects depending upon the situation of the gas-works, local conditions, available coal supplies, and residual markets; and the plant which most satisfactorily meets the requirements of one undertaking may prove less successful in another differently situated.

From the economic standpoint, the most desirable carbonizing plant is the one best equipped to meet the variation in the commercial values of coal and residual products. First, consideration must be given to the special requirements of the particular undertaking; and in this respect the efficiencies of various types of carbonizing plant, having regard to local conditions, come under review.

The types of plant in general use may be summarized as follows:

1. Complete gasification plant, giving a high yield in gaseous therms, with no residuals except liquid products.
2. Vertical retort installations, giving a high yield in gaseous therms with steaming, reduced quantity of coke of low calorific value, and maximum liquid products.
3. Coke and chamber ovens, giving a medium yield in gaseous therms, special quality of coke, and maximum liquid products.
4. Horizontal retort installations, giving a high quality of gas, with medium yield in gaseous therms, domestic coke, and residuals.

The variations in the arrangements of the above types of plant are well known, and are much too numerous to come within the scope of a paper of this description. It is the author's intention first to deal generally with the special circumstances affecting the selection of carbonizing plant at the Stretford Works.

The works, on transfer to the Stretford and District Gas Board in September, 1923, occupied a site of approximately 7⅕ acres adjoining the Bridgwater Canal. The first work carried out by the Board was the laying down of a railway siding, which, owing to the situation of the main line and existing plant, had to be brought in on the side of the works opposite to the canal. The then existing carbonizing plant consisted of two benches of 8 beds, each bed set with 8 horizontal retorts, 22 in. by 16 in. by 20 ft. long, D-shaped, in three tiers, with 6-in. ascension pipes on both sides of the retort benches, operated by an electrically-driven charging and discharging machine supplied from continuous overhead coal hoppers supported from cross girders on stanchions erected independently of the brick-built retort house.

Coal stores were provided on both sides of the house; and for handling canal-borne coal, a trunk elevator, shovel-fed from the barges, and a steel plate conveyor were utilized to convey the coal to a breaker pit and elevator on the canal side. A corresponding breaker pit and elevator was in use on the discharging side of the retort house; and this was also fed from the canal by means of an electrically-driven coal telpher and grab running on a reinforced concrete telpher track across the gable end, and thence parallel to the retort house to the breaker pit. The elevator on the discharging side was also used for feeding rail-borne coal, which was carted into the works to the retort house. The removal of coke from the house was by means of telpher machine and track passing through the gable end to storage ground, with quenching tank immediately outside the house.

The maximum capacity of the coal-gas plant was then 2,250,000 c.ft. per diem. In addition there is a carburetted water gas plant of a capacity of 500,000 c.ft. per diem. The maximum capacity of the gas-making plant was, therefore, 2,750,000 c.ft. per diem. It should be here pointed out that the condensing, washing, and scrubbing plant was barely sufficient to deal with the then maximum make of coal gas.

During 1923 there was a large increase in the consumption of gas. The send-out for the year was 641,000,000 c.ft., as compared with 485,000,000 c.ft., the output in year 1921. The maximum daily send-out during the winter of 1923-24 was 2,609,000 c.ft. compared with a maximum of 2,138,000 c.ft. in the previous winter. The margin of spare gas-making plant available was, therefore, exceedingly small.

The district served by the undertaking includes the intense industrial area of Trafford Park, as well as a rapidly growing residential area; and it was considered that in the laying-down of new plant it would not be prudent to take as the figure of growth the usually accepted figure of 5 p.ct. per annum compound increase, but to provide for 7½ p.ct., which is equivalent to doubling the output in approximately ten years. It was obvious that extensions could not be carried out without involving a large expenditure for the alteration and removal of existing plant, as the works, in part, were far too congested. Moreover, the coke and coal handling arrangements were cumbersome and costly in operation.

The general trend of development in carbonizing plant in recent years has been in the direction of obtaining the highest possible yield in heat units in the form of gas rather than in the form of gas and residual products. It will be freely admitted, however, that it does not necessarily follow that the highest yield in gaseous heat units will mean the cheapest gas, especially at times when prices of residuals are high in relation to the price of coal; and as the Stretford undertaking is situated in close proximity to the Lancashire and Yorkshire coalfields, where plentiful supplies of cheap gas-making slacks are available, this consideration was one which primarily influenced the author in the selection of plant.

The main points affecting the selection may be summarized as follows:—

1. The works are conveniently situated, with low carriage rates by rail and canal, for the purchase of cheap gas-making slacks. As an indication of value in this respect, it may be stated that the average price of good-quality washed or dry slack of ½-in. size is, on the values of the past twelve months, approximately, 6s. to 7s. per ton less than the price of gas nuts from the same seams. It was considered essential, therefore, that the selected plant should be capable of successfully carbonizing fine slacks.
2. A good local demand for gas coke exists in the area; there being large buyers for industrial purposes, and also a large and extensive market gardening demand in the out-districts.
3. In view of the rapid growth of the undertaking, it was considered desirable that the gas to be supplied should be of high calorific value, in order to defer as long as possible capital expenditure in providing mains of increased capacity, also in the provision of additional gas storage.
4. It was considered essential that the capital cost should be kept as low as possible compatible with efficiency, as the undertaking had recently changed hands, in the process of which the standing capital charges had been increased by 140 p.ct.
5. The plant generally should be such as could be worked in a manner to reduce to a minimum laborious work.
6. The conditions of the Gas Regulation Act necessitate at the present time that the yield of gas should be of a continuous and even quality.

It may, to a certain extent, be claimed that the three principal systems at present in use for high-temperature carbonization—*i.e.*, vertical retorts, chamber ovens, or horizontal retorts—would meet these requirements.

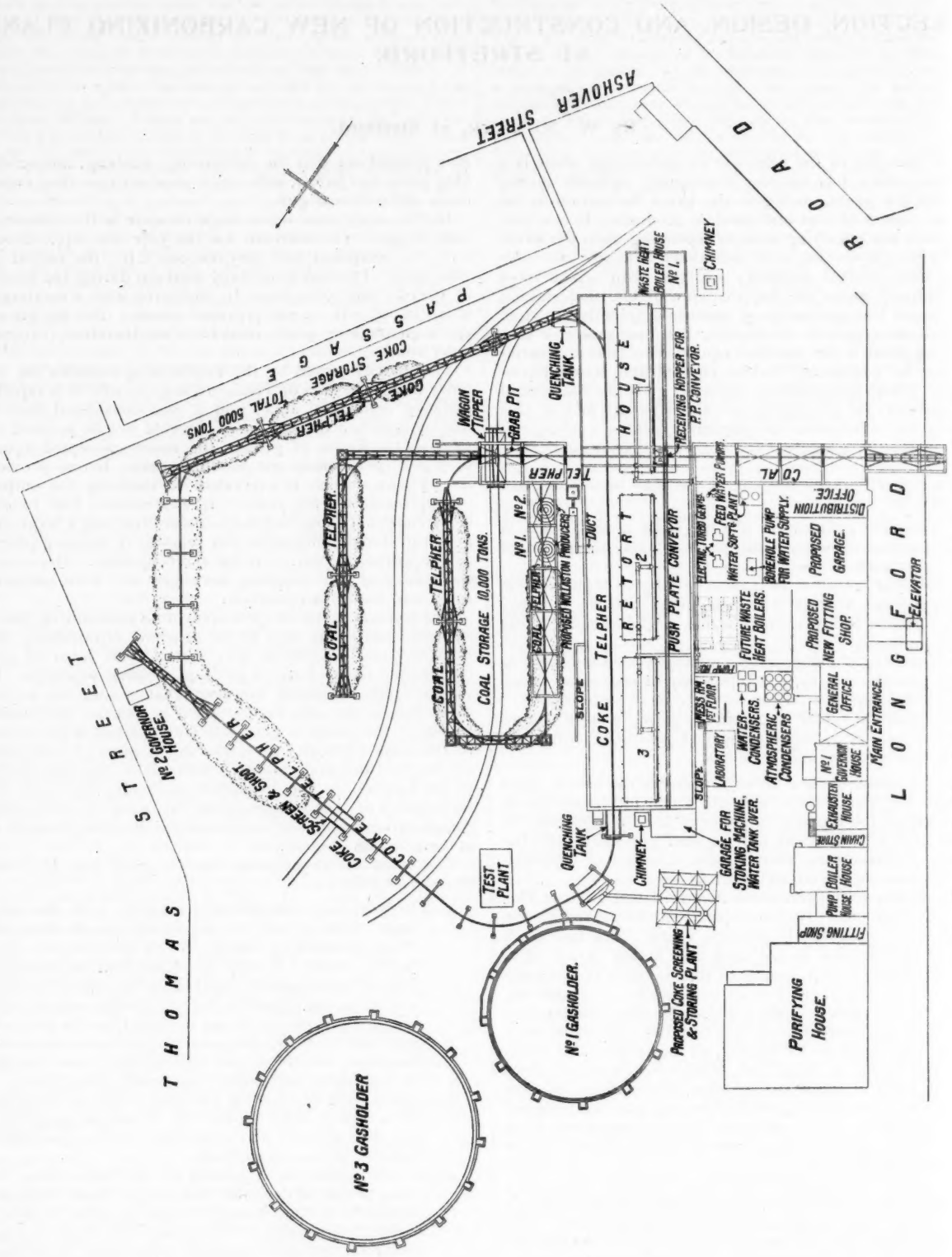


FIG. 1.—GENERAL SCHEME.

The advantages of a vertical retort installation over the other two systems lay in possible lower labour costs and cleaner working conditions. It was considered, however, that these would not outweigh the disadvantage in the matter of higher costs occasioned by restricted choice of coals, especially in the case of the Stretford undertaking, where only slacks are carbonized.

The small coke oven or chamber oven installation, such as has, in recent years, been extensively put down in America and on the Continent for gas-works purposes, offered attractions in that increased efficiency in the matter of fuel consumption was claimed in the case of ovens heated by means of reversible recuperators with gas from outside producers. The disadvantages of this type of plant are that the units are somewhat large for a medium-sized undertaking, and arrangements for charging and coke handling are not so simple as when dealing with smaller retort units. Moreover, with a large unit and long carbonizing period there is the possibility of greater variation in quality between charging times, especially having regard to the size of the plant as a whole.

Careful estimates were prepared of the probable working costs on a make of 650,000,000 c.ft. per annum, with a chamber oven and with a horizontal retort installation, taking the raw coke consumption of chamber settings with reversible regenerators and outside producers at 12 p.ct., and at 15 p.ct. in the case of the ordinary horizontal retorts, from which it appeared that the additional revenue from the extra yield of coke would be almost counterbalanced by the extra capital charges. Moreover, the class of coke produced from fine slacks in chamber ovens would probably have been unsuitable for domestic purposes.

There was a further consideration affecting the selection of plant—viz., that a portion of the new plant should be available for gas-making for the winter of 1924-25, in view of the increased output, and horizontal retorts, being more standard practice than chamber ovens, could be more rapidly installed. It was therefore decided to extend the existing horizontal retort house by the addition of a new bench of 9 beds, each containing 10 horizontal retorts 24 in. by 18 in. by 22 ft. long, and on completion of this extension to reconstruct the existing house, and replace the existing benches by two benches each of 8 settings on the same lines as the extension; making the total capacity of the extended and reconstructed carbonizing plant 6,000,000 c.ft. of straight coal gas per 24 hours, the whole of which could be operated by one set of stoking machinery, and coal and coke handling plant.

The advantages of the type of plant selected, so far as the Stretford undertaking is concerned, are:

1. Any class or grade of gas-making coal can be used down to the finest slacks.
2. The capital outlay necessary is the minimum, having regard to the site and conditions as to coal and coke handling.
3. Residual yield in the form of coke is high in relation to the coal carbonized, on account of more efficient heating and less radiation losses than with vertical retorts.
4. Maintenance charges are low, and horizontal retorts are easily repaired when in operation.

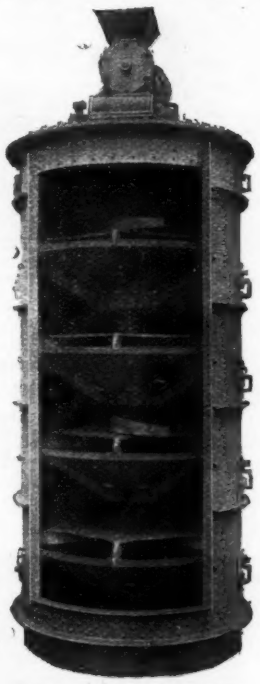


Fig. 2.—Wollaston Producer.

The carbonizing plant as laid down, and in course of construction, has several new and important features; and before dealing generally with the design of the plant, it would be as well to call attention to the circumstances which led up to the new departures in the arrangements for the heating of the settings. None will gainsay that considerable economies could be effected were it practicable to utilize coke breeze for the purpose of heating retort settings. At the time the type of plant to be installed was under consideration, the author had occasion to carry-out a series of tests on a gas producer installed for the purpose of boiler firing, which had been specially designed to gasify cheap slacks. In the course of these tests it was decided to test the producer running on coke breeze.

The plant in question was designed by Mr. T. Roland Wollaston, M.I.M.E., of Manchester, and consists of a producer of normal design with a super-imposed chamber or retort through which the fuel is passed over a series of trays, by means of mechanically-operated turning arms, until it reaches the producer itself (see fig. 2). The object of this retort is to enable the producer to handle a wide range of fuels, and to gasify fine slacks containing a large percentage of ash. Efforts have previously been made to coke or partially coke the incoming fuel to a producer by the outgoing producer gas, but with partial success only. The principal cause of failure was indirect heating causing uneven coking; and the swelling properties of the coal have prevented the free passage of the gas, and direct and intimate contact with the whole body of the fuel. In the "Wollaston" retort, the fuel is not packed together, but is spread out, and kept in motion in the chamber, in which there is ample room for the passage of the hot gas in intimate contact with the fuel. Furtner, the mechanical action ensures that all particles of the fuel are exposed and subjected to direct heat transference. As a result, a fair percentage of the volatiles are distilled off, and the finest slack on discharge from the retort is sufficiently coked to form a good producer fuel. When operating on coke breeze, the retort acts as an efficient drier; and no difficulty was experienced in successfully gasifying breeze which had been passed through a ¼-in. mesh. It would appear, therefore, that the difficulties previously experienced in gasifying breeze in forced-draught producers were due to the moisture content closing the interstices in the breeze particles lying in close contact, so preventing the free passage of the blast.

As a result of the foregoing experience, the author concluded that there were considerable advantages to be gained by the use of outside producers which could successfully gasify coke breeze or the cheapest slack coals, as the fuel would be very much cheaper than the gas coke used in the self-contained producers. Against this, however, must be taken into account the radiation from the producer, and the sensible heat of the gas which is lost in the case of external producers. The difference in overall heat efficiency on account of these losses is approximately 16 p.ct.

Outside producers have previously been used for heating retort settings. The heating efficiency of such producers is, however, naturally less than the self-contained type using coke in both instances, but to the extent of utilizing coke breeze their economy is certain. An advantage of external producers is that a portion of the gas therefrom can, in case of necessity, be used as a diluent for the straight coal gas from the horizontal retorts, when it is desired to reduce the calorific value of the gas made to (say) 500 B.Th.U. for the purpose of distribution.

Following an investigation of the possible economies consequent upon the heating of the settings with gas from outside producers using cheap fuels, the question of heating by coal gas was taken into consideration, as it has often occurred, in the case of gas-works situated in the vicinity of the coalfields where cheap supplies are available, that the yield from residuals equals the cost of coal, or nearly so. In such instances, where there is a sufficiency of carbonizing plant, the heating of the settings by coal gas is an economic proposition.

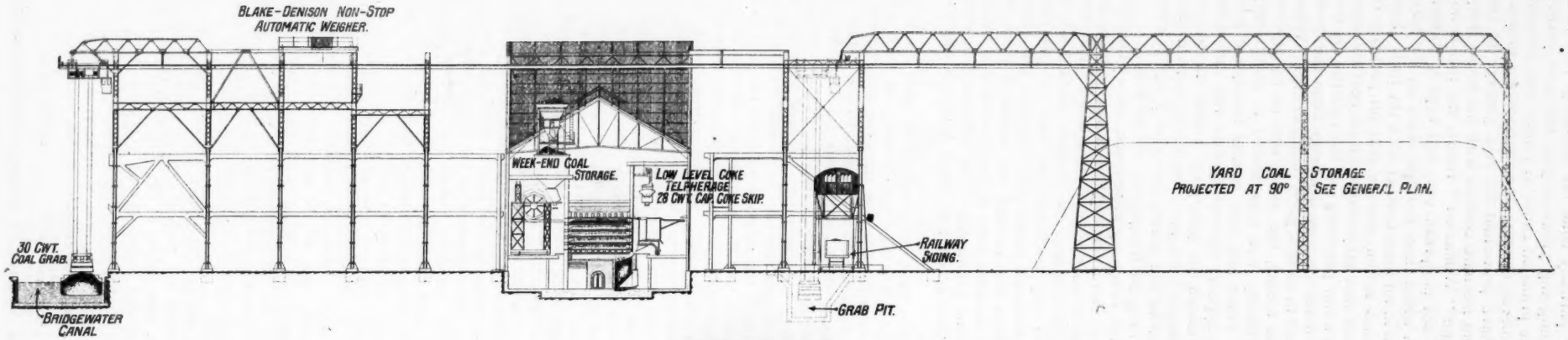
Assuming the thermal efficiency of carbonization is 80 p.ct., and of gasification of coke in producers 75 to 80 p.ct., the cost per therm of coal gas or producer gas may be taken as being proportionate to the prime cost of the fuel; and, generally speaking, when the value of coke is higher than the price paid for coal, the heat units produced as straight coal gas are cheaper than the heat units produced from coke as producer gas.

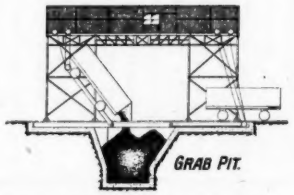
The average efficiency of the ordinary self-contained producer utilized for heating retort settings does not normally exceed 80 p.ct. Allowing, however, for the advantage of the sensible heat of the self-contained producer gas, which is lost when firing with gas from outside sources, it is safe, for the purposes of making a comparison of the cost of gas and coke firing, to take 40,000 c.ft. of coal gas (of, say, 520 B.Th.U. per c.ft.) as being equal to one ton of coke.

Assuming the retort-house cost of coal gas 6d. per 1000 c.ft. (the actual net cost of coal gas averaging 520 B.Th.U. per c.ft. into holder at the Stretford Works during the twelve months ended March 31, 1924, was 5·7d. per 1000 c.ft.) the relative costs of heating by gas and coke are as follows:

Gas, 40,000 c.ft. at 6d. per 1000 c.ft. = 20s.
as against
Coke having a works value of . . . . 27s. 6d. per ton.

These figures, on the basis of per ton of coal carbonized,


BLAKE-DENISON NON-STOP AUTOMATIC WEIGHER.
WEEK-END COAL STORAGE.
LOW LEVEL COKE TELPHERAGE. 28 CWT. CAP. COKE SKIP.
YARD COAL STORAGE PROJECTED AT 90° SEE GENERAL PLAN.
30 CWT. COAL GRAB.
BRIDGEWATER CANAL
RAILWAY SIDING.
GRAB PIT.



SECTIONAL ELEVATION OF DOUBLE 20 TON TRUCK TIPPER.

FIG. 3.—COAL GRAB AND TELPHER DETAIL.

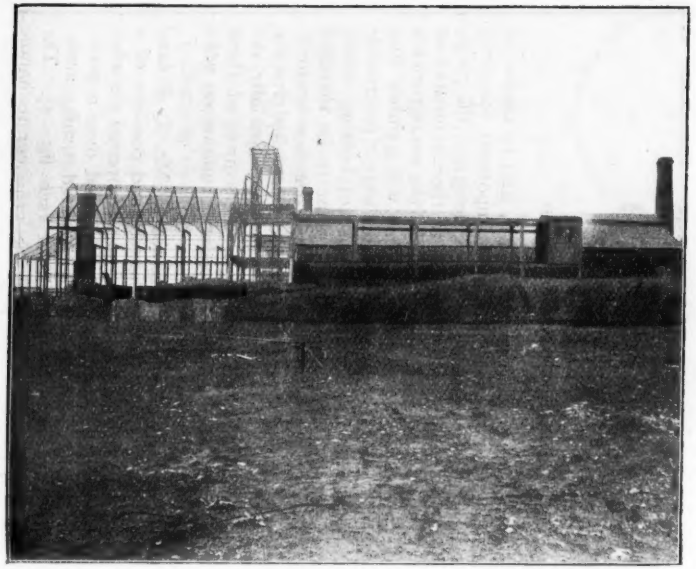


FIG. 5.—EXISTING HOUSE AND EXTENSIONS IN COURSE OF CONSTRUCTION

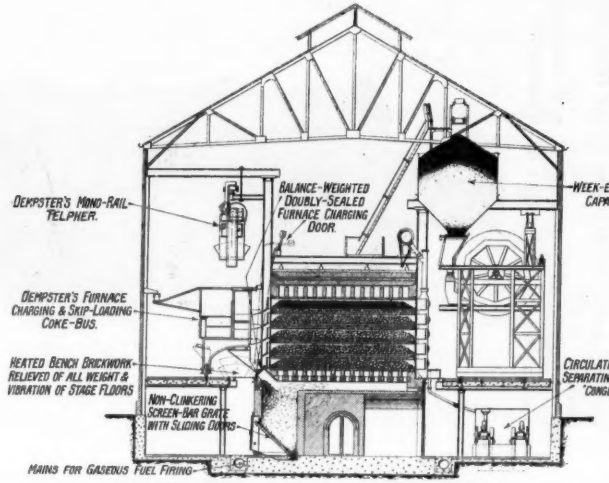

DEMPSTER'S MONO-RAIL TELPHER.
BALANCE-WEIGHTED DOUBLY-SEALED FURNACE CHARGING DOOR.
WEEK-END COAL CAPACITY.
DEMPSTER'S FURNACE CHARGING & SKIP-LOADING COKE-BUG.
HEATED BENCH BRICKWORK RELIEVED OF ALL WEIGHT & VIBRATION OF STAGE FLOORS
NON-CLINKERING SCREEN-BAR GRATE WITH SLIDING DOORS
CIRCULATING PUMPS & SEPARATING TANKS FOR "CONGOON" PIPES.
MAINS FOR GASEOUS FUEL FIRING

FIG. 6.—CROSS-SECTION OF NEW HOUSE.

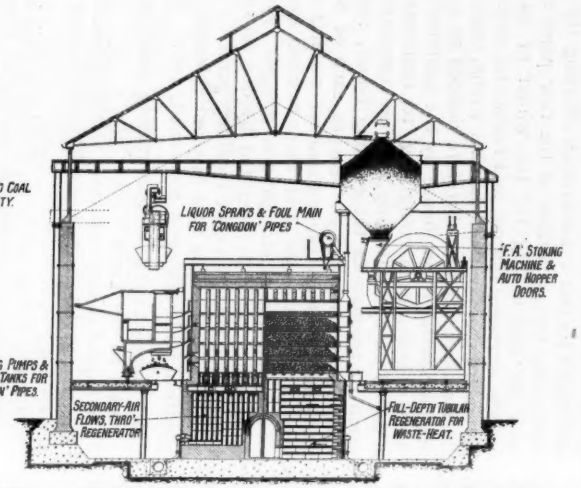

LIQUOR SPRAYS & FOUL MAIN FOR "CONGOON" PIPES
"F.A." STOKING MACHINE & AUTO HOPPER DOORS.
SECONDARY-AIR FLOWS, THRO' REGENERATOR
FULL-DEPTH TUBULAR REGENERATOR FOR WASTE-HEAT.

FIG. 7.—CROSS-SECTION OF OLD HOUSE RECONSTRUCTED.

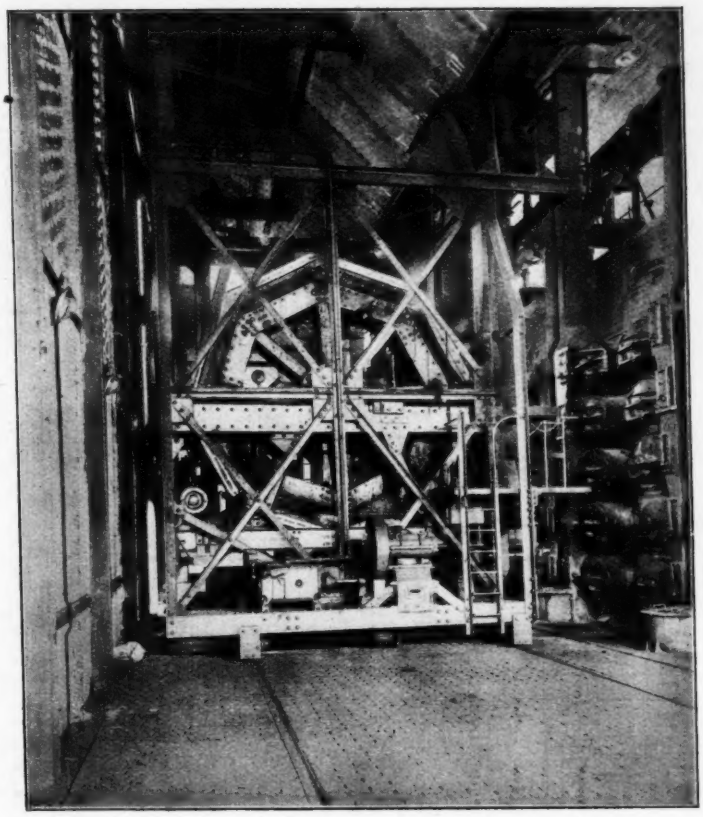


FIG. 8.—"F.A." STOKING MACHINE.

assuming that the coke consumed in the furnaces is 2½ cwt. per ton of coal, would be:

Coke firing	=	3s. 5½d. per ton of coal carbonized
Gas firing	=	2s. 6d. " " " "

In the case of the figure of the cost of gas firing, there is, however, an additional 2½ cwt. of coke per ton of coal which would be available for sale on the total throughout —equivalent to 3s. 5¼d. per ton of coal carbonized. After deducting the extra wages costs (at, say, 1s. 6d. per ton) on the additional weight of coal to be carbonized, the net cost of gaseous firing per ton of coal is 6¾d.—equivalent to a gross difference of 2s. 10½d. per ton of coal carbonized. It should here be pointed out that no account has been taken in the foregoing figures for maintenance and capital charges on the extra carbonizing plant necessary in the above circumstances if the settings were entirely heated by coal gas; and a reasonable estimate for the above is 17d. per ton. This reduces the possible saving by coal-gas firing by one-half.

On the basis of the above figures, during the year 1924, had surplus carbonizing plant been available, and the whole plant adapted for firing by coal gas, a saving of approximately £4000 could have been effected on a make of 641 million c.ft.

The foregoing conclusions have been put forward in this paper as indicating the line of thought which led up to the evolution of the special regenerator setting which has been installed at Stretford.

It has been pointed out that it was essential that the plant should be in operation for the heavy load in the winter of 1924-25; and the time available would not permit of the immediate laying-down of auxiliary external producers such as the author has indicated, and which were then only passing from the experimental stage. It was decided, therefore, that the settings to be erected should be arranged with self-contained producers to work on normal lines, and, alternatively, for gaseous firing from external sources with producer gas, coal gas, or a mixture of both. It was considered essential to the efficiency of this latter provision that the gas and air for purposes of combustion should enter the combustion chamber of the setting at approximately equal temperatures; and to this end the author in conjunction with Mr. H. J. Toogood, of Messrs. Robert Dempster & Sons, Ltd., of Elland, the contractors for the retort benches, evolved a special setting which is provided with a self-contained producer of large area, and in addition has separate and distinct regenerator flues heated from the waste-gas flues, both of which are used for pre-heating the secondary air when the setting is working with its own producer, and which can be used alternatively for heating gas and air when firing with gas from external sources.

DESIGN OF PLANT.

The general arrangement of the carbonizing plant, with coal and coke handling plants, is shown on the plan (fig. 1). A factor affecting the design of the coal handling plant was that the facilities for receiving coal by rail or canal should be maintained. At the same time, it was desired to concentrate the coal storage, as far as possible, on one side of the house, instead of on both sides, as existed. In order to provide sufficient space for the extension of 9 beds, it was necessary to remove a portion of the existing reinforced concrete coal telpher track passing across the gable end of the retort house. It was decided to adopt electrical telpherage for the coal handling, as by this arrangement the whole of the coal, except that required for stock, could be elevated in one operation. The new track between the Bridgwater Canal and the railway is carried over the top of the existing concrete trestles with girders spanning the retort-house extension, and is extended beyond the railway on steelwork towers and girders in two arms over the coal stores, running at right angles to the main track. The arm nearest the retort house is returned along the top of the old ferro-concrete structure parallel to the house to be utilized for feeding the proposed external producers.

The plant has a capacity of 40 tons per hour, and is capable of dealing with coal by means of a 30-cwt. grab either from barges on the canal or from the grab pit which is fed from the railway by a double-ended wagon tipper of the overhead type arranged to deal with 10-20 ton trucks, so that delivery from either end of the track is possible without turning round. To carry the super-imposed steelwork, and also the larger and heavier machine, the reinforced concrete structure is strengthened by means of external channels and internal angles strapped together across the columns of the concrete trestles, the

FIG. 5.—EXISTING HOUSE AND EXTENSIONS IN COURSE OF CONSTRUCTION

FIG. 6.—CROSS-SECTION OF NEW HOUSE.

MAINS FOR GASEOUS FUEL FIRING—

FIG. 7.—CROSS-SECTION OF OLD HOUSE RECONSTRUCTED.

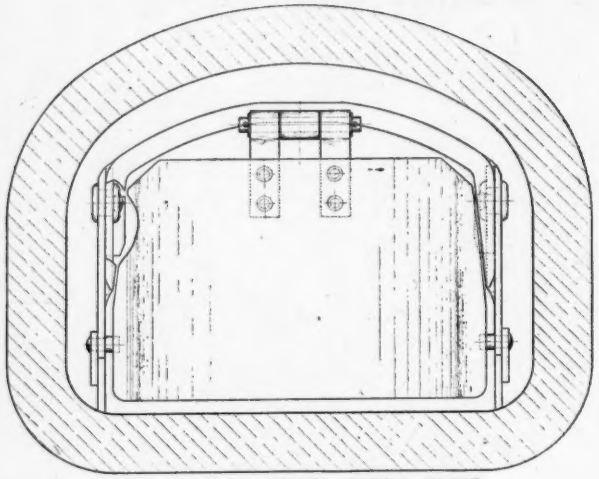


FIG. 9.—"F.A." CHAIN, INSIDE DRIVE.

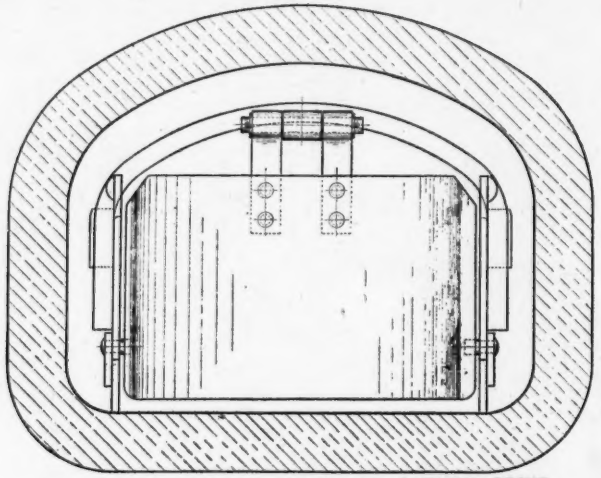


FIG. 10.—"F.A." CHAIN, STANDARD OUTSIDE DRIVE.

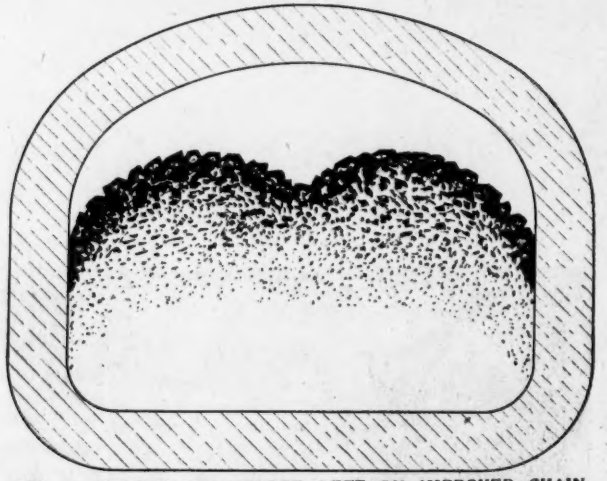


FIG 11.—SECTION OF CHARGE LEFT BY IMPROVED CHAIN WITH OUTSIDE DRIVE.

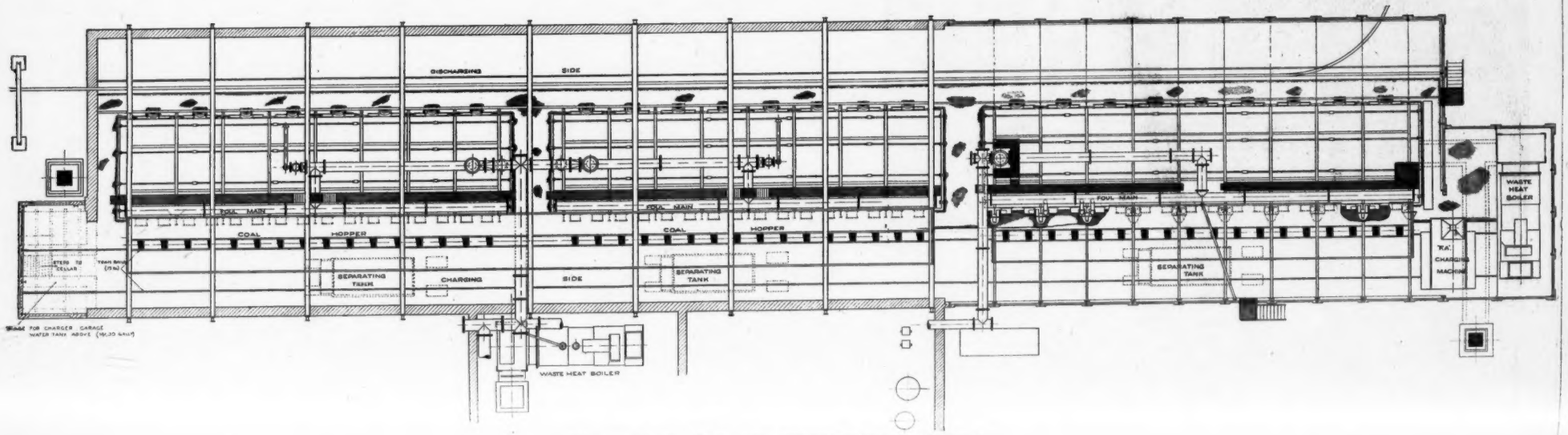


FIG. 12.—PLAN, NEW AND RECONSTRUCTED BENCHES.

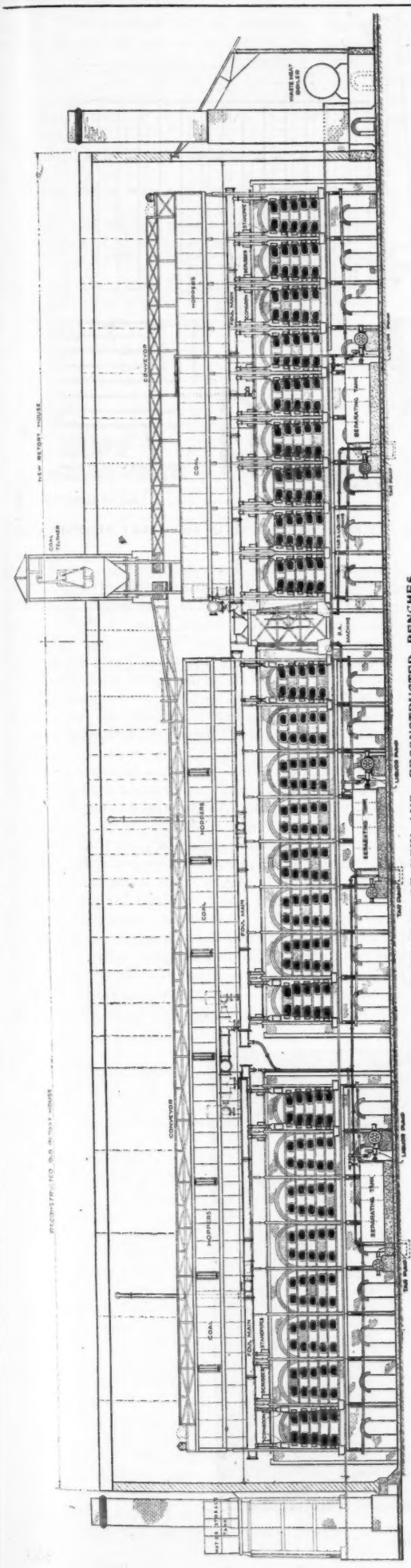


FIG. 12.—PLAN, NEW AND RECONSTRUCTED BENCHES.

FIG. 13.—ELEVATION OF NEW AND RECONSTRUCTED BENCHES.

whole being braced with diagonal angles, the foundations being increased proportionately for the extra loading.

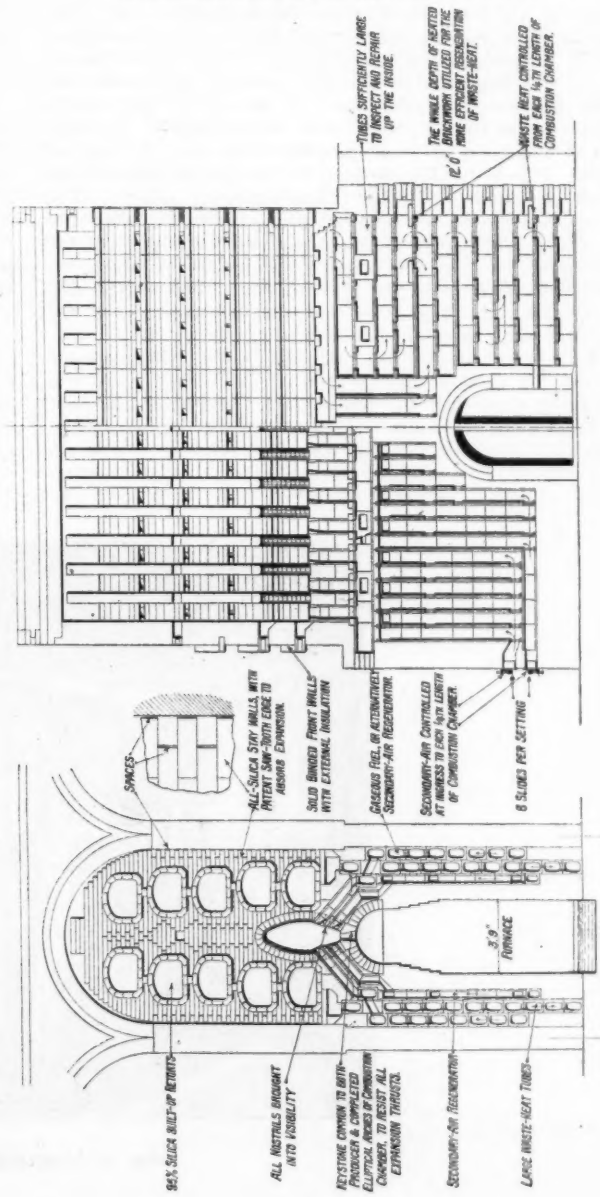
The increased height of the track over the existing reinforced concrete track is 23 ft. 6 in., making the total height 69 ft. It is carried over the retort house by 75 ft. span girders, and is roofed and sheeted with asbestos corrugated sheets to meet the retort-house roof. This cover forms the housing for the telpher machine. For weighing the coal received by canal barge, a Blake-Denison non-stop automatic weigher is installed on the telpher track between the canal and the retort house.

The general details of the coal telpherage plant are shown on the plans and illustrations appended (see figs. 1, 3, and 4*).

The coal is delivered by the telpher machine into a receiving hopper which, in turn, is arranged to feed the push-plate conveyors supplying the overhead bunkers in the extended house, and in the existing house, as shown in fig. 3. The coal hoppers and telpher track in the old retort house are carried on cross girders supported by steel stanchions independently of the building; and in order to provide for the larger benches with five tiers of retorts, these girders are raised by means of lengthening the existing stanchions 10 ft., and will carry the new coal hoppers and telpher track in the reconstructed portion (see fig. 7).

The overhead hoppers have a capacity of 48 hours, and are fitted with "A. & G." automatic doors which enable the stoking machine to take its charge as it travels from one retort to the next (see figs. 6, 7, and 8). The stoking

* The illustration is too large for reproduction in the "JOURNAL."


TUBES SUFFICIENTLY LARGE TO INSPECT AND REPAIR OF THE INSIDE
THE WHOLE DEPTH OF HEATED BRICKWORK UTILIZED FOR THE MORE EFFICIENT ABSORPTION OF WASTE HEAT.
WASTE HEAT CONTROLLED FROM EACH 1/5TH LENGTH OF COMBUSTION CHAMBER.
12'0"
SPACES
ALL-SILICA SIDY WALLS WITH PATENT SAW-TOOTH EDGE TO ABSORB EXPANSION
SOLID BONDED FRONT WALLS WITH EXTERNAL INSULATION
GASEOUS FUEL OR ALTERNATIVELY SECONDARY-AIR REGENERATOR
SECONDARY-AIR CONTROLLED AT INGRESS TO EACH 1/5TH LENGTH OF COMBUSTION CHAMBER
6 SLOTS PER SETTING
3'9" FURNACE
95% SILICA BUILT-UP RETORTS
ALL INSTALLS BROUGHT INTO VISIBILITY
KEYSTONE COMMON TO BOTH PRODUCER & COMPLETED ELLIPTICAL ARCHES OF COMBUSTION CHAMBER, TO RESIST ALL EXPANSION THRUSTS.
SECONDARY-AIR REGENERATOR
LARGE WASTE-HEAT TUBES

FIGS. 14 & 15.—DETAIL ELEVATION AND SECTION OF REGENERATOR SETTINGS.

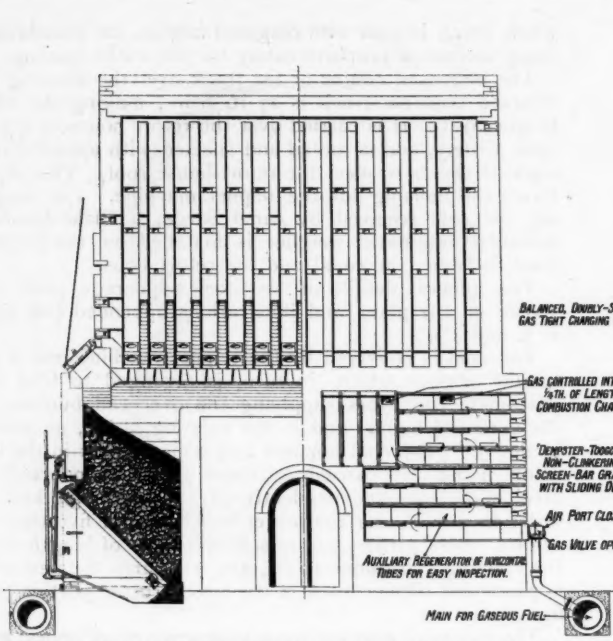


FIG. 16.—DETAIL GASEOUS FIRING IN AUXILIARY REGENERATOR.

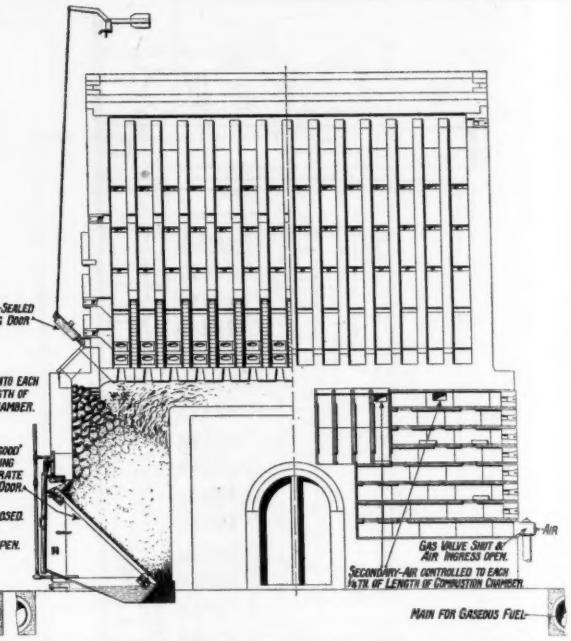

BALANCED, DOUBLY-SEALED GAS TIGHT CHARGING DOOR.
GAS CONTROLLED INTO EACH ¼TH. OF LENGTH OF COMBUSTION CHAMBER.
"DEMPSTER-TOOGOOD" NON-CLINKERING SCREEN-BAR GRATE WITH SLIDING DOOR.
AIR PORT CLOSED.
GAS VALVE OPEN.
GAS VALVE SHUT & AIR INGRESS OPEN.
AIR
SECONDARY-AIR CONTROLLED TO EACH ¼TH. OF LENGTH OF COMBUSTION CHAMBER.
MAIN FOR GASEOUS FUEL.

FIG. 17.—DETAIL COKE FIRING IN AUXILIARY REGENERATOR.

is done by a Fiddes-Aldridge simultaneous stoking machine, which is of an improved standard type in that the driving blocks for conveying the power from the charging wheel to the chain are on the inside of the chain instead of on the outside, as was the case in the original "F.A." standard machine (see figs. 9 and 10). The result of this alteration is that it is possible to increase the width between the side plates of the chain, and obtain greater capacity of coal, and, consequently, a much heavier charge than was possible with the old type of chain. This is further assisted by the special push plates, which are made of a light heat-resisting alloy. The charges are even; and on the withdrawal of the chain are left with a slight depression caused by the trigger of the front push plate in the centre of the charge, which ensures free passage of the gas and also reduces the distance which the heat has to travel to the core of the charge in the process of carbonization (see fig. 11).

The main reason for adopting the simultaneous machine as against the projector type is ability of the former to deal with the finest slacks and dant, without the creation of nuisance. Further, it has an advantage in quicker operation. The weight of charge can, with silica retorts, be burnt-off in an 8-hour period with combustion chamber temperatures of 1325° to 1350° C. The author considers that the latter temperature can only be exceeded at the expense of the life of the settings.

The general arrangement of the new retort benches in the extension and in the old retort house is shown on the plan and elevation appended (see figs. 12 and 13).

The retort settings (see figs. 14, 15, 16, and 17) are built in semi-circular arches 8 ft. 9 in. span with 18-in. pier walls between the neighbouring hot portions of the setting, and 14 in. pier walls below stage-level, between the relatively cold regenerators. The special double regenerator disposed on either side of the waste-gas flues is cellular in construction. The tubes are staggered so that all joints are covered, in order to prevent leakage. Further, a two-ply thin partition divides the descending waste-heat flues and the ascending secondary-air or gas flues, as the case may be. The construction is such that any crack which might develop in one tube is opposed by the wall of the adjacent tube. The depth from stage floor to cellar is 12 ft.; and the whole of this is utilized for the regeneration of waste heat. The waste-heat, secondary-air, and gas flues are controlled into each quarter length of the combustion chamber. The waste-gas tubes are horizontal, for easy inspection, and are sufficiently large to be repaired from the inside. The gas regenerator, which is on the outside of the waste-gas tubes, is similarly ar-

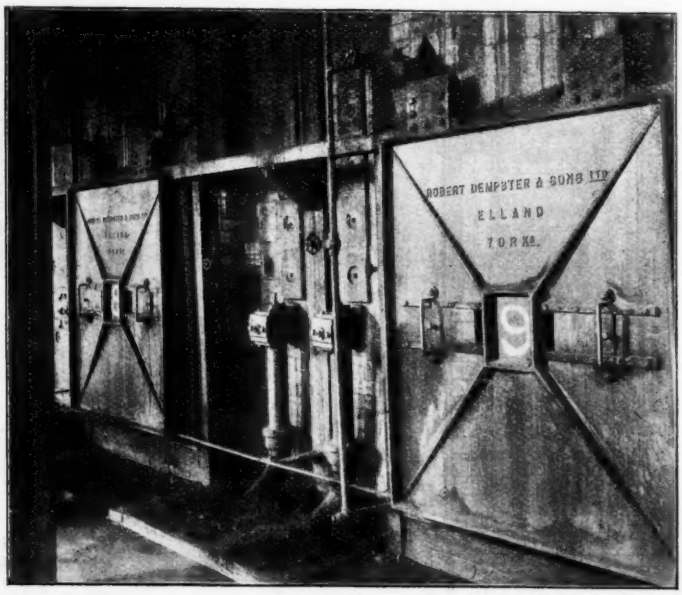


FIG. 18.—FURNACE DOORS.

ranged. The gaseous fuel or secondary air, as the case may be, is carried across the top of the waste-gas tubes, in cross ducts, to a large distribution chamber feeding the nostrils. The tubes in the secondary-air regenerator are arranged vertically, and the nostrils of both gas and air regenerators are brought into visibility in the combustion chamber.

The design of the producer is a good one; the furnace being 3 ft. 9 in. wide by 5 ft. 4 in. back to front with a fuel depth of 7 ft. In the author's opinion it is important, to procure the most economic working and even gasification, that the furnace should be as nearly square as possible. Much higher producer efficiency can be obtained with a wide furnace than with the long narrow shape which was the general practice for so many years.

The furnaces are fitted with non-clinkering adjustable screen-bar grates, and have a grate area of 26·25 sq. ft., 2·39 sq. ft. per 20 ft. of retort. This form of grate obviates the necessity for clinkering, and facilitates an even rate of gasification; the whole grate area being maintained in a lively condition, as the air has ready access to the entire grate. Moreover, there is no dead fire resting upon the ashpan itself. Provision is made for working the producers with steam or water; and at this point it may be mentioned that most satisfactory results have been obtained so far by the former method with almost dry ashpans. The charging doors are of the "Elland" double-sealed gas-tight type; the lids having an annulus which, with the door closed, forms, with the metal sealing face of the frame, a dust-retaining cavity completely surrounding the door, into which cavity dust and breeze swept from the retort-house floor is thrown. The sealing face is steeply inclined, so that the dust, on opening the door, falls away into the fire. The lids are hinged and operated on the Becton balanced lid principle, with counter-balance weights at the top of the bench (see figs. 16 and 17). The sliding ashpan doors of the producers are suspended from an overhead rail on a travelling bogey; and the door

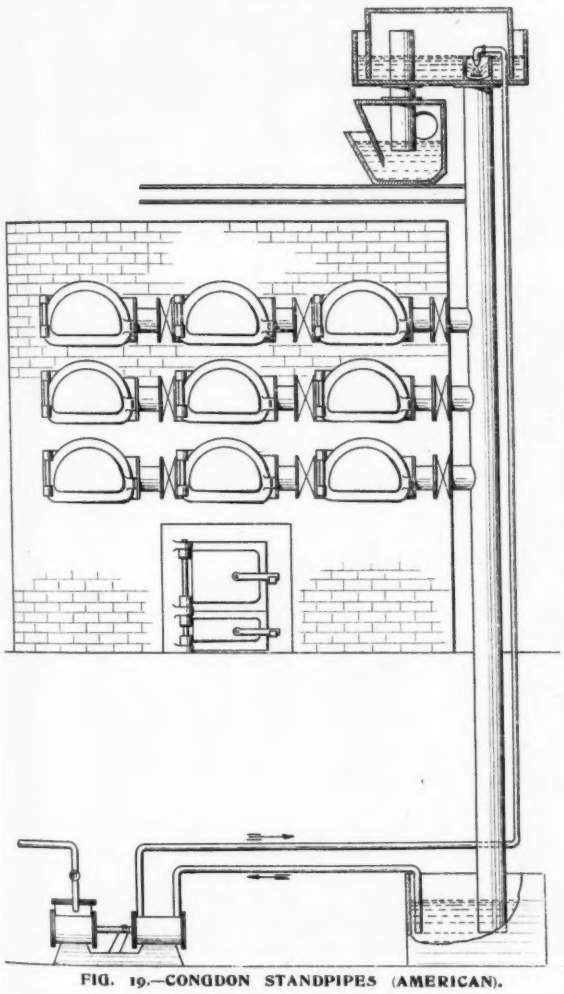


FIG. 19.—CONGDON STANDPIPES (AMERICAN).

frames are flanged so that the machined faces of the frames and doors can be clamped to secure absolute tightness (see fig. 18).

The retorts, which are ⌂ section, 24 in. by 18 in. by 22 ft. long, are built up in 95 p.ct. silica segments, and are set in five tiers supported by thirteen all-silica stay walls 6 in. thick, with patent elliptical combustion-chamber arches in which the keystone is common to the producer arch and to the combustion-chamber arch. This prevents the lifting of the producer-gas arch by unbalanced expansion strains. The flues between the stay walls are 11¼ in. wide, so that, practically speaking, the very high proportion of 60 p.ct. of the retort is exposed for economic heat transmission—and this without sacrifice of strength. The stay walls are built with a saw-tooth edge construction where they abut on the pier walls, and between the retorts, to provide for after-expansion of the silica material (see fig. 14). The double provision for expansion at the point of highest temperature—*i.e.*, between the top three tiers of retorts—with the saw-tooth joints amounts to 2 in. It is interesting to note that, from observations on the heating-up of the settings, these joints have closed, as near as can be estimated, to ⅛-in.

For the purpose of firing the setting with coal gas, or producer gas from external producers, an 18-in. diameter gas main is carried beneath the cellar floor on both sides of the retort bench, and is connected to the auxiliary regenerators on each side by two 4-in. connections provided with a specially-designed gas valve for regulating the supply of gas to the setting (see figs. 16 and 18). The front walls of the settings and top of the retort bench are insulated with 4½-in. thickness of porous insulating bricks.

It will be observed from the foregoing description and a perusal of the diagrams that the setting meets all the requirements of modern practice as is generally accepted for efficient horizontal retorting with self-contained producers. With regard to the operation of gaseous firing with gas from external sources, it is proposed that the setting should be first started-up under coke firing, and then changed on to gaseous firing either by coal gas or producer gas. It is desirable, of course, to close-off the producer; and the most simple manner of doing this is to charge the fire with a layer of breeze, which, after the closing of the primary air openings, will smoulder away, leaving the furnace fully ashed up. Alternatively sand or brickdust may be thrown on the surface. When passing back to coke firing, this can easily be broken-up. This procedure is only suggested as an additional precaution beyond the closing of the primary air openings, and the sealing of the furnace door. When the setting is being coke fired, the auxiliary regenerator is used for pre-heating the secondary air, which is admitted above the gas valve by means of a special port in the body of the valve above the seating. (See figs. 16 and 17.)

A departure has been made from standard practice in this country by the adoption of Congdon scrubber standpipes in place of ascension pipes and hydraulic mains. It has previously been mentioned that the existing condensing, washing, and scrubbing plant was sufficient only for the maximum make of gas in 1922; and it was considered that the adoption of the scrubber standpipe would assist in reducing the work on the purification plant.

The design of the standpipes as originally used in America (see fig. 19) was not, in the writer's opinion, such as would give efficient scrubbing or equal conditions as to pressure on all retorts; the pipe being of the same area throughout its length, though the volume of gas at the top is very much greater than at the bottom. The scrubbing effect on the gas from the top retorts must, in these circumstances, be very small.

A further objection to American practice was that the standpipes are reduced in area at the bottom, and connected to a tar pipe which conveys the tar and liquor to seal pots located in the cellar below the stage-floor, with possibility of stoppages arising in the down-take pipes, should any deposited pitch or carbon be forced through into the standpipes when cleaning the outlets from the mouthpieces. Moreover, the down-take pipes and seal pots prevent free access to the regenerator flues, and the seal pots themselves are not under the direct observation of the stokers on the stage-floor of the house.

After careful investigation, it appeared that the neces-

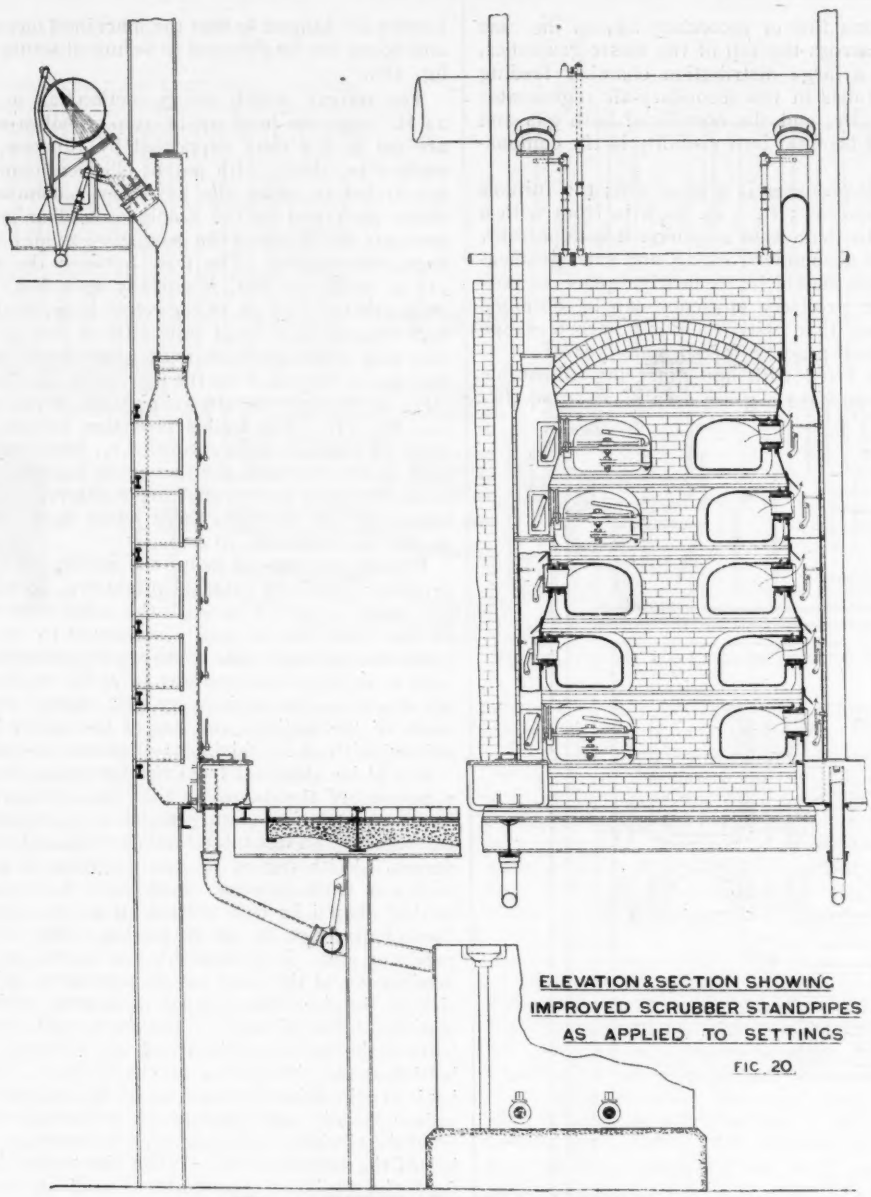


FIG. 20.—CONGDON STANDPIPES (IMPROVED).

sary conditions for the success of the scrubber standpipes were :

1. The area of the standpipe should increase in proportion to the volume of gas passing, to ensure maximum scrubbing effect and maintenance of equal pressure on all retorts.
2. The seal box to be at stage-floor level, the bottom of the standpipe forming a part of the seal box with direct access under the dip plate, should any foreign matter or pitch accumulate at the bottom of the standpipe.
3. Direct observation of the tar and liquor overflow from the seal boxes, which should be provided with tight covers easily removable.
4. The tar and liquor pipes connecting the separating tanks with the seal pots at stage-floor level should be arranged to avoid interference with access to the regenerator flues.
5. The standpipes to be suspended in such a manner as to allow free movement on the expansion of the setting taking place.
6. Connections between the mouthpieces and standpipes to be as short as possible, and allow movement, vertically and horizontally, to the extent of maximum expansion.
7. Provision to be made for quickly isolating any standpipe when required.
8. Operating valves for shutting-off retorts to be easily removable for inspection.
9. Connections between standpipes and foul mains to be of large area, and provided with expansion joints.
10. Liquor sprays to be arranged suitably, for easy cleaning and inspection.

An improved scrubber standpipe (see figs. 20, 21, and 22) was designed on the basis of these desiderata. The standpipe is increased in area by two steps; the maximum area being opposite the top retort. At this point it might be mentioned that, on the eighteen beds now under construction in the existing retort house, it is proposed to carry up the standpipe to a greater height above the top retort, with baffle plates to disperse the liquor and increase the scrubbing capacity (see fig. 23).

The seal boxes are made D shape; two standpipes being connected to each seal box, the bottom of the pipes being level with the bottom of the seal boxes. The dip plates at the front of the standpipes are arranged to give a seal of 6 in. The 4-in. overflow pipe is provided with a notched weir for measuring the rate of flow of the liquor from the standpipes. Easily removed covers are fitted to the seal pots, for inspection purposes, and for cleaning out when required.

The standpipes themselves are of cast iron in two castings. The bottom casting receives the connections from the three bottom tiers of retorts, and is formed to connect-up with the seal box. The top casting receives the connections from the top two tiers of retorts, and at the top is formed into a socket to receive the 9-in. diameter

connecting pipe to the foul main. The standpipes are 1 ft. 6 in. from back to front for the full height, 7⅛ in. wide to the height of the second tier, 11½ in. to the height of the fourth tier, and 15⅝ in. wide at the fifth tier. The connections between the standpipes and the mouthpieces are 7-in. diameter, and are taken-off from the side of, and at right angles to, the mouthpiece; the distance between the inside of the mouthpiece and the face of the valve in the standpipe being 7⅞ in. Socket pieces, which form a V-shaped valve seating on the inside, and 2¾-in. socket externally, are bolted to the standpipe; and the connection between this socket and the mouthpiece socket is made by a special sleeve, the external portion of which is ground to spherical radii struck from the axis of the sleeve at the centre of each socket, so as to permit free movement of the sleeve in any direction in its own packings when expansion is taking place (see fig. 20).

The valves, which consist of plain cast-iron spherical discs hinged to bell-crank levers, are designed for easy removal. The stuffing-box bearing mounting the axle to which the operating lever is connected is contained in a detachable plate bolted to the front of the standpipe; and the plate, with the valve attached, can be withdrawn by removing the set-screws securing the plate to the standpipe (see fig. 20). Inside the standpipes, immediately above each valve, deflection plates are provided set at an angle to the vertical side of the pipe, to deflect the liquor on to the face of the valve when open, to ensure: First, that the gas passing from the mouthpieces will meet a stream of liquor; and secondly, to assist in keeping the faces of the valves clean. A further object of these deflection plates is to prevent liquor travelling round the face of the valves, and so into the mouthpieces.

The standpipes are suspended from brackets attached to the front buckstays by hanging bolts, so as to permit of forward movement, on expansion taking place, independently of buckstays (see fig. 21). The 9-in. pipe connection to the foul main is carried vertically for a height of 4 ft. above the stand pipes, where a branch is taken-off at an angle of 36°, connecting into the bottom of the foul main. On this branch pipe there is a socket with special provision for expansion. There is also a faced joint immediately above the socket, in which an isolating disc can be simply inserted by the slackening of two bolts. A 24-in. foul main, to the bottom of which the standpipes are directly connected, runs the full length of the bench; the drainage of this main being through the standpipes themselves. The off-take from this main is at the centre of each bench, to ensure equal conditions as to pressure on all standpipes. Each bench of retorts is controlled by a 14-in. Cowan retort-house governor, and, in addition, Peebles' safety relief governors are fixed on each foul main at the centre of the bench, to provide relief in case

FIG. 21.—CONGDON STANDPIPE, SEAL POT, VALVE PLATES AND LEVER.

of accidental stoppage of the exhausters. Liquor sprays are provided, one on each standpipe (see fig. 24), with two additional ones in the foul main itself. These sprays are specially designed with the spray box external to the pipe; liquor being fed to an annular chamber, and then direct to the spray nozzle. By shutting-off the liquor from the pipe supplying the annular chamber, and opening a cock at the back of the spray box, direct access is given for cleaning. The sprays are easily accessible from the platform running on the top of the bench at the back of the foul main (see figs. 25 and 26).

The 4-in. connections from the seal pots are connected to tar and liquor separating tanks set opposite the centre of each bench, by means of 6-in. tar and liquor mains provided with large inspection covers, for cleaning purposes.

FIG. 22.—RETORT BENCH, CHARGING SIDE.

The 4-in. downtake pipes are immediately opposite the buckstays, and, therefore, do not in any way interfere with access to the regenerator flues.

The tar and liquor separating tanks are 17 ft. 6 in. long, 8 ft. wide, and 5 ft. 6 in. deep, divided into three chambers with baffle plates in each. It has been found since the plant started working that these are of ample capacity to ensure complete separation of the tar and liquor; no tar being found in the last, or liquor, suction chamber. Liquor pumps are provided in duplicate for pumping the liquor over the standpipes; and as the cellar floor is below ground-level, tar pumps are also provided for pumping to the wells the tar run-off daily from the separating tanks.

The scheme provides for two waste-heat boilers. The first boiler is situated at the end of the new extension, and is of sufficient capacity to deal with the waste gases from nine settings. The boiler is of the Spencer-Bonecourt "Kirke" patent type, 8 ft. in diameter by 17 ft. tube length, suitable for a working pressure of 100 lbs. per sq.in., with a superheater capable of giving a superheat of 100° Fahr. A second and larger waste-heat boiler is to be installed of sufficient capacity to deal with waste gas from the sixteen settings in course of construction in the existing retort house. The main flues of all three benches

are inter-connected, and provided with dampers, so that by the operation of these dampers it will be possible to work the waste-heat boilers at their maximum capacity at all times. This was considered to be desirable, as it is the ultimate intention to utilize the waste-heat boilers for the generation of electricity for the whole of the power to the works.

Provision is made in the scheme for two external producers for the gasification of coke breeze or cheap slack, each having a capacity of 12,750,000 B.Th.U. of gas per hour, which will be sufficient for the heating of twelve settings. The producers are to be erected beneath the extension of the coal telpher; and the overhead coal bunkers supplying slack or coke breeze to the producers are to be fed by the telpher machine grab.

On the discharging side of the house an electrically-operated coke bus (see figs. 6 and 27) is provided for feeding coke direct to furnaces or to telpher skips from the top tiers of retorts, whereby labour is saved and breeze formation prevented. The coke is removed from the house by a high-speed telpher machine on to an external quenching bench provided with sliding doors for the discharge of the coke, after quenching, into a receiving hopper feeding a coke breaker and elevator, whence it is taken to overhead screens and storage bunkers. Provision is also made

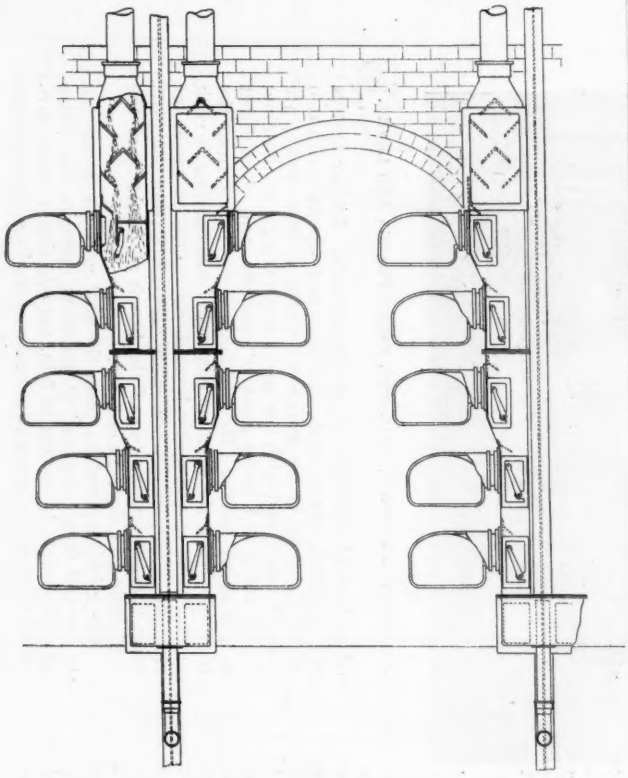


FIG. 23.—DETAILS OF IMPROVED CONGDON STANDPIPE.

for a quenching tank fitted with hinged doors at ground-level at the gable end of the house. These doors are closed by the weight of the skip and opened by counter-weights; the doors being arranged to close before the skip actually touches the water in the tank. A special steam duct from the tank carries the steam away above the level of the retort house. This arrangement is designed to prevent nuisance from the diffusion of steam and coke breeze which arises when quenching is carried out in an open tank.

The telpher track is carried round the coke storage yard to form a continuous loop, so that the telpher machines will travel in one direction only when in operation (see fig. 1). It may be mentioned as a point of interest that the existing coke telpher track has been utilized as far as possible; the foundations of the trestles being increased in height to raise the track to the new level.

A retriever pan-ash washer is installed on the discharging side of the retort house extension, the elevator supplying the washer being carried from cellar floor level. The apparatus is also arranged for feeding from ground level for the purpose of breeze washing.

The stage-floor in the retort house is carried separately from the bench, so that no expansion can be transmitted to the house framing; and chequered plates over the intervening space between the floor and the bench are constructed in a manner to allow an air space to assist ventilation beneath the floors.

The retort house extension containing the first new bench of nine settings is a steel-framed building filled with 9-in. and 4½-in. brick panels. The chequered brickwork panels for ventilation on the sides and gable end are arranged as lettering to form, at the sides, an advertisement reading "Use Gas and Coke," and, at the gable end, "Use Gas." (See fig. 4.)

CONSTRUCTION.

The foundations for the whole of the plant were laid down by the undertaking, employing direct labour. The subsoil is loam and sand to a depth of 6 ft., when a water-bearing gravel bed of 7 ft. thickness is reached. This overlies a stratum of blue clay, which, it is presumed, in turn overlies the red sandstone formation. The depth of this latter has not been proved on the site.

It was not possible to take the foundations down to the clay, on account of the cost; and it was decided to construct the bench foundation as a reinforced concrete raft above the gravel bed—the main bearing points of the raft being the stanchion bases, and the pier walls of the retort bench. Grip steel bar reinforcement was utilized; and fabric reinforcement in flat sheets covers the whole of the bottom of the foundation, in order to disperse over the whole area the portion of the load distributed between the 18-in. pier walls of the bench. Distribution of the load from the end and side stanchions and 18-in. piers is ensured by continuous beam reinforcement alternating from the top to the bottom of the foundation, according as the bending moment is positive or negative. Particular attention was paid to the ash-pan pockets, which were specially reinforced with ¾-in. stirrup rods, to distribute the load. In no case does the whole of the loading on the ground exceed two tons per sq.ft. The average thickness of the concrete foundation is 2 ft.; and by the method of reinforcement adopted, greater strength is obtained than could have been secured by massed concrete, and at much less cost. The pipe trenches formed in the foundation to receive the gas mains for the supply of fuel gas to the settings have special fabric reinforcement.

The erection of the new benches in the existing house required the deepening of the cellar floor to the extent of 4 ft., to provide for the deeper settings; and this necessitated the breaking-up of the existing massed-concrete foundations, 4 ft. in thickness. For this purpose hydraulic cartridges were used; the method of operation being to drill a hole 5 in. in diameter in the concrete, and insert a hydraulic cartridge, which consists of a steel cylinder, 18. long, containing four plungers which can be expanded 2½ in. from the circumference of the cartridge. The cartridge is wedged in the hole by steel wedges driven in front of the plungers, which are extended by hydraulic pressure supplied by hand through a screw pump until a fracture in the bed of concrete is made. The maximum pressure exerted by one cartridge is 400 tons.

The large blocks of concrete were afterwards broken-up by means of pneumatic picks operated by compressed air. The cost of demolishing the concrete foundations by this means worked out at 22s. 6d. per c.yd.

The contract for the whole of the work, with the exception of foundations, stoking machine, and improved Congdon standpipes, which were supplied by Messrs. Aldridge & Ranken, Ltd., of Bath, was let to Messrs. Robert Dempster & Sons, Ltd., Rose Mount Iron Works, Elland, on March 19, 1924. The work on the foundations for the retort-house extension was commenced on March 20, 1924; and these were completed ready for the contractors in the space of twelve weeks.

The steelwork framing of the retort house, stage floors, stanchions, and retort-bench bracing, amounting in weight to 220 tons, was erected complete in 57 working days. The whole of the work on the extension, including the building of the retort benches and construction of the steelwork telpher track superimposed on the reinforced con-

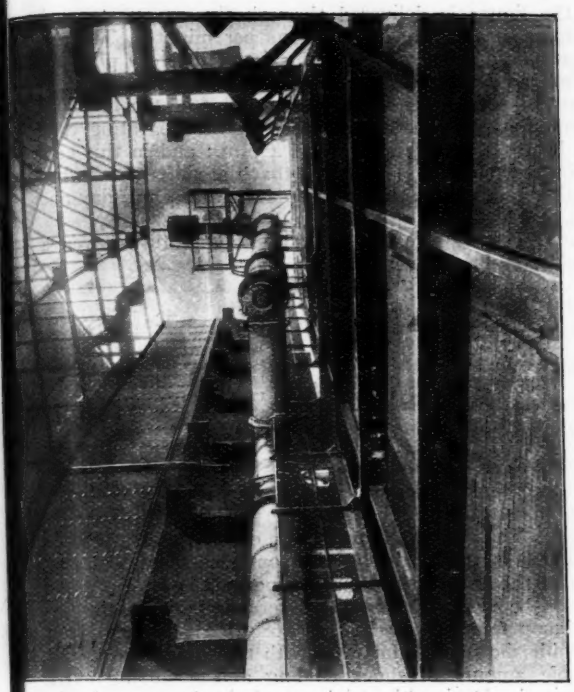


FIG. 23.—ACCESS PLATFORM.

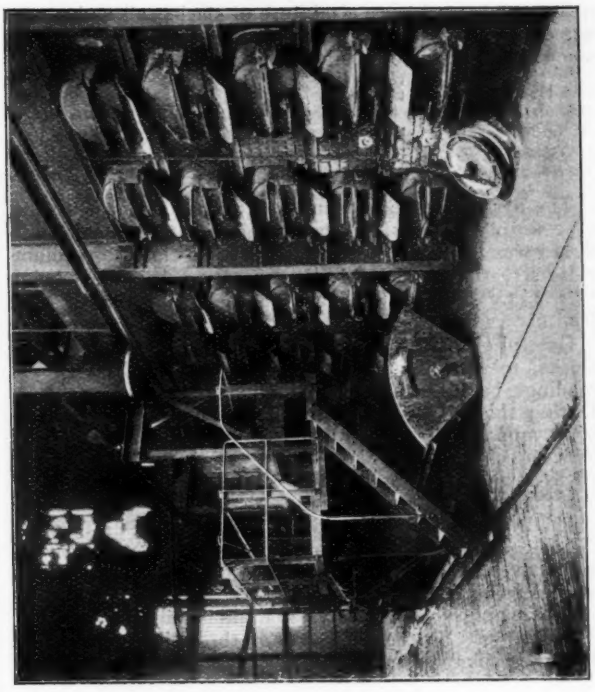


FIG. 27.—COKE BUS (DISCHARGING SIDE.)

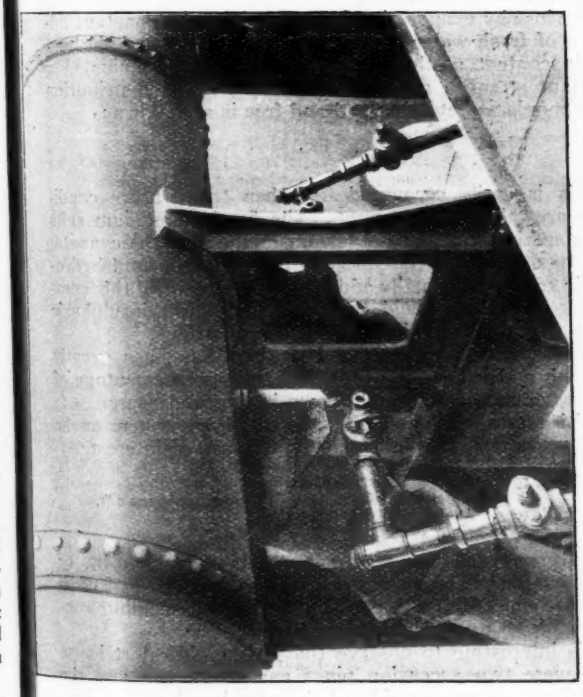


FIG. 24.—LIQUOR SPRAYS AND STANDPIPE.

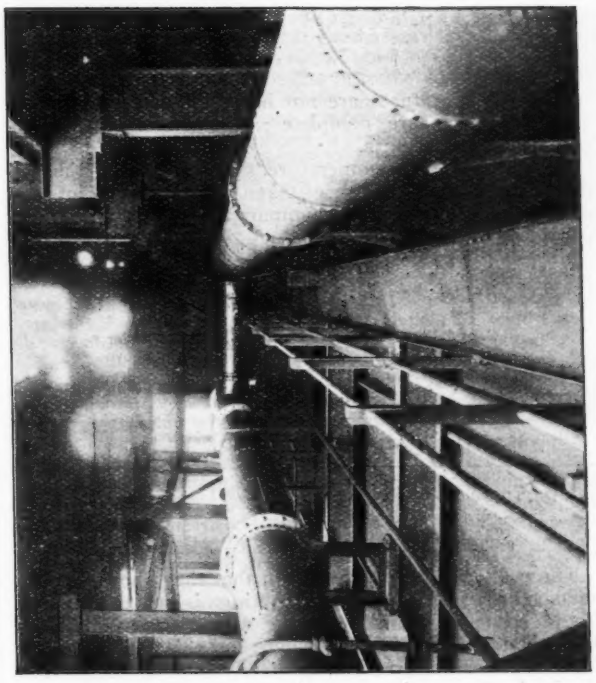


FIG. 26.—TOP OF RETORT BENCH.

crete telpher track between the canal and the grab pit, was completed by Nov. 26, 1924, and gas-making was commenced on the new plant on Jan. 10 of this year. The difficulties of construction were accentuated by the fact that the existing retort benches had to be worked to their maximum capacity until the extension of the house was completed.

WORKING RESULTS.

The first new bench of nine settings has been in operation for a period of four months; and some interesting data have been obtained of the working results. The settings have so far only been worked with their own producers, as it has not been possible to attempt coal-gas firing, owing to the reconstruction in progress and sufficient plant not being available. Further, the external producers have not yet been erected. The results, however, prove that the setting working with its own producer is highly efficient.

The following figures are the result of a six days' experimental run:

Duration of charges	12 hours
Coal carbonized	710·4 tons
Gas made	9,896,000 c.ft.
Make per ton (corrected)	14,360 c.ft.
Average calorific value	529 B.Th.U.
Therms per ton	75 96
Coke made	497 tons 6 cwt.
Coke used on producers	70 tons 19 cwt.
Coke available for sale per ton of coal carbonized	12 cwt.
Coke consumed on producers per ton of coal carbonized	2 cwt.

The average analysis of gas made during the period of test is as follows:

	P.Ct.
CO_2	3·4
O_2	0·4
C_nH_m	2·0
CO	10·0
CH_4	26·3
H_2	51·0
N_2	6·9

Average total inerts, 10·7 p.ct.

The coals used were a mixture of slacks, all under 1 in. screened size, drawn from Lancashire and Yorkshire seams; the proximate analysis being as follows:

	P.Ct.
Moisture	3·3
Organic volatile matter	30·0
Ash	11·0
Fixed carbon	55·7
Total	100·0

The average coke consumption on producers is 10 lbs. of coke per 100 lbs. of coal carbonized. The coke produced was of good-grade quality of fine-close to medium-close structure, and hard; the average ash content being 15·3 p.ct. The heat balance on the basis of the above trial shows a net efficiency of carbonization of 82·04 p.ct.

Careful observations were taken over a period of eight weeks, to ascertain the heating efficiency of the settings; readings being taken with a Siemens optical pyrometer. During this period the settings were on 12-hour carbonizing, operated in two 8-hour shifts, and 4-hour periods between charging. The normal weight of charge was 16 cwt.; and with regard to this item, it should be pointed out that a large portion of the coal used consisted of washed fine slack, which does not flow so easily through the hoppers and stoking machine as dry slack. When working on the latter, an average charge of 17 cwt. can be maintained.

The average temperatures maintained in the combustion chambers on the nine settings throughout the period of eight weeks are as follows:

	Average Temperature, °C.
Setting No. 1	1253
,, No. 2	1287
,, No. 3	1285
,, No. 4	1286
,, No. 5	1295
,, No. 6	1293
,, No. 7	1296
,, No. 8	1301
,, No. 9	1278

These temperatures are not high, but were more than sufficient to ensure complete carbonization within the period of twelve hours.

To ascertain the temperature gradient within the settings, daily readings were taken at various points, of which the following is a summary:

Points where Readings were Taken.

A. . . . . Combustion chamber.
B. . . . . Top of the settings, at a point where the gases divide above the top tiers of retorts.
C. and D. . . Left and right sight holes under bottom tier of retorts above waste-gas flue.
E. . . . . Temperature of waste gases in the main flue.

—	A.	B.	C.	D.	E.
Max., °C.	1370	1017	955	940	620
Min., °C.	1230	940	815	847	460
Average, °C.	1302	988	900	905	538

These figures are interesting in that they show that the balance of heat throughout the settings is well maintained. The average CO_2 content of the waste gases is 16 p.ct. There is a slight excess of oxygen; but this does not reach 1 p.ct. These figures substantiate the good fuel results obtained. The producers work without need of clinkering, and easily maintain the temperatures with the combustion chambers under pressure.

The standpipes have so far proved most satisfactory in operation. The provision made to meet expansion proved to be adequate; and though in some instances the forward movement of the front wall of the settings, due to expansion, was as much as ¾ in. horizontally and 7-16 in. vertically, in the case of the top retorts, this was easily met by means of the suspension adopted and the spherical sleeve connections between the mouthpiece and standpipe sockets. When opened up for examination, the standpipes showed a slight film of tar about $\frac{1}{32}$ in. thick covering the sides and valves.

Equal conditions as to pressure are easily maintainable on all retorts: the retort-house governor being worked with approximately $\frac{1}{20}$ in. vacuum on the inlet. On opening the valves when charging, it is observed that the gas is practically in a state of equilibrium. The pressure maintained on the delivery side of the liquor pump is 10 lbs. per sq.in.; and the liquor is delivered through the sprays to each standpipe at the rate of 5 gallons per minute. There is an automatic relief valve on the liquor delivery pipe, returning the excess liquor to the separating tank.

Daily observations of the temperature of the liquor in the standpipe seal pots and outlet of the separating tank have been taken at 10 a.m. and 4 p.m.; and in this connection it should be pointed out that the shift hours when charging takes place are from 10 a.m. to 6 p.m., day and night shifts.

The following are the average temperatures over a period of eight weeks:

—	Time.	Max.	Min.	Average.
		°Fahr.	°Fahr.	°Fahr.
Seal pots	10 a.m.	191	151	181
	4 p.m.	199	181	190
Tank	10 a.m.	170	154	163
	4 p.m.	183	168	178

The cooling of the liquor in its passage through the separating tank varies on the average from 18° Fahr. at the commencement of the charging period to 12° Fahr. at the end. The average temperature of the gas leaving the standpipes is 179° Fahr. at the commencement and 199° Fahr. at the end of the charging period.

It will be observed that the difference between the gas and liquor temperature is only 16° to 21° Fahr. It is noticeable, however, that even with this difference a considerable amount of shock cooling and scrubbing effect is obtained. During the trial run of six days, previously referred to, the tar drawn from the settling tank was measured, and was found to be equivalent to 49·04 lbs. per ton of coal carbonized.

The loss by evaporation is made up by the constant addition of fresh water to the separating tank, and the ammonia content of the liquor in circulation remains at a constant strength averaging 11·6 ozs. The distribution of ammonia as between fixed and free is as follows:

Fixed	11·2 ozs.
Free	0·4 ozs.

This is easily accounted for when temperature conditions are taken into account. The fixed ammonium salts contained in the liquor are largely ammonium thiocyanate; and the action between sulphuretted hydrogen and hydrocyanic acid is continually adding to the content of this compound. Sulphurous acid, sulphuric acid, and thiosulphuric acid are present only in very small proportions.

The work on scrubbers and washers has been greatly relieved; and it has been found that a large percentage of the free ammonia is brought down in the condensers.

With regard to the effect of the standpipe system on the sulphur content, the following figures are of interest:

April, 1924.	Average H_2S content on the inlet of purifiers	749 grs. per 100 c.ft.
April, 1925.	Average H_2S content on the inlet of purifiers	594 ,, ,, ,,

The average decrease was 155 grains per 100 c.ft., or 20·7 p.ct. on the 1924 figures. The same class of coals were carbonized in both periods; the average sulphur content being 2·55 p.ct. on dry coal basis.

It is interesting to observe that in the old retort house there were two ascension pipes per retort, whereas the standpipes are on one side of the new bench only. Previous experience has been that H_2S in gas from horizontal retorts with one ascension pipe is higher than two. The lower sulphur content with the standpipes is doubtless due to the effect of ammonia washing.

The period of operation of the plant has not been sufficiently long to permit of the collection of accurate data with respect to the yield of the liquid products; and in giving the foregoing results, the author has confined himself specially to the results bearing most directly on the new features which it has so far been possible to record.

Discussion.

The PRESIDENT: We have heard a most instructive engineering paper on carbonizing and the reconstruction of a gas-works. I have had the privilege of seeing these works, not since they were completed, but during the time they were in progress; and I can only say that Mr. Carr is to be congratulated on being able to take a plant which required considerable modification and utilize it so as largely to increase the output. He has had a difficult task at Stretford, because, as you have heard,

Stretford is an intensely industrial area, and the increase in the demand for gas was very considerable. Therefore Mr. Carr is to be congratulated on being able to reconstruct these works, and also supply a greatly increased demand. You all remember that his father, Mr. Isaac Carr, was noted as being the one who supplied the cheapest gas in the world. I venture to say that Mr. W. M. Carr is following in the footsteps of his father. The figures he has given us show the efficiency of the plant that he has introduced, and he has also adopted some very novel methods with reference to carbonizing. I am sure there is a fund of matter in the paper which would probably take us a day if we were to discuss it adequately; but I should like one or two of those present to enter into the discussion. Any questions that you may care to put, I am sure Mr. Carr will be pleased to answer. As Mr. Toogood has been mentioned in connection with the plant, perhaps he will say a word or two.

Mr. H. J. TOOGOOD: As a visitor, I appreciate very highly the permission to say a few words in connection with this contribution. First of all, I must congratulate Mr. Carr upon a very splendid paper. It is crowded with most interesting facts. As many of you will be aware, the chief reason for my connection with the Stretford installation is that Mr. Carr, when he selected his scheme of carbonization, elected to place his order with the firm of Messrs. Robert Dempster & Sons, whom it has been my privilege and pleasure to serve for the past 21 years. During this long association it has been my lot to be connected with various forms of carbonization. So that there shall be no misunderstanding, I would just like to say that in 1904 I was chiefly engaged on stoking machinery; in 1908 I was engaged on intermittent vertical retorts; in 1911, with continuous retorts; and now I stand on the platform with horizontal retorts. But I do not want you to think that there has been any variaion whatsoever, inasmuch as the consistent theme running through the whole of that experience is the development of the machinery of carbonization; and it is under the head of the development of the machinery of carbonization that I venture to discuss Mr. Carr's paper. As Mr. Carr has headed his paper "Selection, Design, and Construction of New Carbonizing Plant at Stretford," I venture the opinion that the lesson of this paper will be remembered for many years as "cheap gas, and how to get it *via* residuals." As an example of this, I would mention Mr. Carr's father, Mr. Isaac Carr, whose name is brought to mind by the very mention of the words cheap gas. The author of this paper has, metaphorically speaking, been reared in an atmosphere of cheap gas; and he will therefore be a champion, second to none, of cheap gas.

In reading the paper, one is struck by the bed-rock principle which underlies the whole of the reasoning—viz., to keep the net cost of coal as low as possible. Consequently the lay-out of the works is really very unique. Mr. Carr did not mention destruction in the title of the paper; but in order to get the plant of his heart's desire, he has had to destroy a considerable amount of good work. Now you will see the theme. He has had to get a retort house wedged between the railway and the canal; so that the widest possible fields for the purchase of cheap coal are, as it were, brought to the door of his retort house. The actual plant is described at length in the paper; but I would like to express it from my own point of view. He has chosen a 70 ft. high-level telpher; and the arrangements are such that he can check the coal from the canal or from the railway or from stock. Though he may have coal from a hundred sources, and cheap coal, the mixture that gets into the retorts is a desirable blend, and he gets coke which is consistently good for his Stretford coke market. Under this head, I suggest that Mr. Carr's paper is quite eligible for the Coke Competition organized by the Editor of the "GAS JOURNAL." Mr. Carr has explained the difficulties at Stretford when this plant was being considered, the chief of which was that the plant must be working for the winter. Therefore, there was very little time to design it. Moreover, the coal to be carbonized was slack; and as the plant had to be working for the winter, Mr. Carr laid it down that there must be nothing of an experimental nature. Nevertheless, the Stretford coke market was always in evidence as being a primary feature in the production of cheap gas; and therefore it was realized that, if the net cost of coal could ever be brought down to nothing, then many economic factors in gas manufacture would be turned topsy-turvy. It was to seize upon this opportunity that Mr. Carr decided to go forward with optional gaseous firing.

Being partly responsible for the design of a portion of this new setting, I would, with your permission, just like to run through its salient features. With regard to the retorts, these have been designed to carbonize slack which is sometimes wet and sometimes dry; but there is always a heavy charge to be carbonized in regular time periods. It was expected that we should have to go to higher temperatures of carbonization; and therefore 95 p.ct. silica retorts were adopted. That these retorts are gas-tight, and that they do their work well, is borne out by the 75 therms per ton of slack with a 10 lb. fuel consumption. The side walls of the retorts were likewise 95 p.ct. silica bricks; the idea being that the retorts would live when the expansion of the silica gave, so to speak, an even keel, so that the gas-tight qualities of the retort should not be disturbed. A space of 2½ in. was allowed on the top of the wall under the crown of the arch on account of this upward expansion; and this space has been virtually absorbed, thus bringing out a fact, never known before, that silica structures expand considerably more than does a solid silica brick when tested in a muffle in a laboratory. To absorb the side expansion of silica walls is much more difficult, as it must be absorbed within the one arch of the setting. Otherwise it would be cumulative down the side, and consequently, in long settings, would be disastrous. To prevent this, the side walls were saw-toothed or staggered. This prevented any squat and consequent leak. No timber was used, for the simple reason that timber burns away at one period; and therefore, since silica expands over a long period, it was felt that timber would leave a space, and a space within a structure like a setting, to say the least, is an unknown quantity, which we were better without. As regards heat transmission, Mr. Carr has said that the walls are 6 in. thick, and the flues 11 in. wide. This means that 60 p.ct. of the retorts are exposed to rapid heat transmission, which has turned out to be effective by the very low fuel consumption. As regards the producer, we believe that the producer is the driving force of any setting, and therefore too much attention cannot be given to its design. But we had a narrow arch with which to work, and we had to put in extra regeneration; yet we wanted a large producer. By scheming the regenerators and utilizing the full depth of the solid brickwork, some 12 ft., we were enabled to get in a producer of 26 sq. ft. area. The grate for this producer was on the screen-bar principle, which has not been in evidence for more than three years. To those who have had no experience of how this type works, it will come as a revelation to witness it in operation. With a smooth, steep perforated screen, such as in the screen-bar grate, the coke slips completely down; whereas with a step grate the coke tends to rise at every step. With a screen-bar grate, the coke continually creeps downwards, while the ash gravitates from the pan. With regard to the regenerators, for the purpose of fuel consumption you cannot have regenerators too large; but here, as I have said, we had only a small space, and therefore the settings consist of a nest of tubes. There are no flues other than tubes. The waste heat descends the centre row. Each of the tubes in the centre row opens to the outside wall; consequently, each being 12 in. by 9 in., you can examine it and clean it and repair it. The secondary air on coke firing passes up through the outside pairs of tubes. The excess air passes up the second pair, and the excess fuel to be preheated passes up the tubes near the walls. These tubes form a very thin division between the waste heat and the secondary air, and consequently are economical in heat transmission, and yet give a double safeguard to preserve efficiency.

Mr. H. H. COLLETT (Sheffield): I heartily congratulate the author on having given us a paper which contains a tremendous amount of food for thought; and I am sure we shall all study it at our leisure, because it is a little difficult to discuss it off-hand. We can then adopt his principles if we are so inclined, because a great amount of ingenuity has been displayed. With regard to the silica retorts, I should like to know whether they are made of 95 p.ct. silica throughout—*i.e.*, whether both the arch and the floor are of 95 p.ct. silica. Then with regard to the liquor circulation. I take it, from what Mr. Carr says, that the liquor which comes from the Congdon standpipes flows down into a tank, and is pumped over again. The temperature of that liquor is very high, and I should like to ask if there has been any trouble with this high temperature. I remember in Leeds we circulated liquor in a similar manner, and got a result, on analysis, very similar to that of the author. It was very high in fixed ammonia and low in free ammonia; but we certainly had trouble with the wrought-iron pipes through which the liquor was sent, and considerable trouble with the pumps. The piston rods had to be renewed fairly frequently, owing to the very corrosive effect of this liquor, which was high in chlorine. I must join issue with Mr. Carr with regard to the quenching of the coke. From my experience, I do think that quenching coke in telpher skips by dumping it into tanks is a bad thing; and I am sorry that Mr. Carr has adopted what I should regard as a retrograde step. Personally, I think the quenching of coke can be very much better done in front of the retort benches by means of hoses. We do that in Sheffield. It is very satisfactory, and we are very seldom troubled with coke fires. In fact, during the whole of last winter, we did not have a single coke fire or the suspicion of one on the heap. I am very pleased to see Mr. Carr speaks so highly of the Congdon standpipe, particularly as I have heard not very good reports of it. Mr. Carr has given us a good report, and no doubt this is due to the modifications which he has so ingeniously applied to it. There is just one other question. What gas is Mr. Carr supplying in his district? Is he supplying a straight 520 B.Th.U. gas, or is he diluting it with water gas? That is an interesting point I should like to be clear upon.

Mr. W. B. LEECH (Gas Light and Coke Company): As one of the judges in the Coke Competition, I would like to warn Mr. Carr that he is already disqualified. [Laughter.] I should like, however, to add my thanks to him for this excellent paper, because I am sure it will be appreciated by all the members, and especially those engineers who are contemplating extensions to their carbonizing plant. The selection of new carbonizing plant is always a difficult problem, each type having so many points in its favour; and certainly I have always found it a very difficult thing to arrive at a really satisfying decision. Mr.

Carr seems to have threshed the matter out, and certainly from his paper I am obliged to agree with him that horizontal retorts are better than any other type for his particular purpose. In fact, I am very much in agreement with him all through, with the exception of one or two small matters. Perhaps I might mention the section of the retorts. I notice Mr. Carr has gone in for 24 in. by 18 in. We have had rather long experience of this type at Beckton, but have found they are rather on the large size for our class of coke. We have many 22 in. by 16 in.; and while it is difficult to say there is an advantage in this size, we find them easier to work, and fancy the coke is better. We also imagine that we get more therms. We have been making experiments recently, and have set up in one of our houses a 24 in. by 18 in. and a 21 in. by 15 in. retort; but I cannot give you results, because we have had a little trouble with the hydraulic main. However, a very interesting fact has shown itself. Both these retorts are charged with a projector type of machine, and as there is no free space between them they are at the same temperatures. Yet the free carbon in the tar from one retort is double that from the other. With regard to it not being wise to work at temperatures from 1325° to 1350°, we work for long periods up to 1400°, and have not noticed any effect upon the setting. Therefore I should like to know what reasons the author has for setting a limit to the temperature. I notice his setting is designed with a special combustion chamber arch to prevent the lifting of the combustion chamber arch itself and the walls of the retorts. We have had rather a strange experience. Previously our trouble has been through the expansion of the silica lifting the centre portion of the walls, and raising the inner side of the retorts, sometimes to the extent of 4 in. or 5 in. Since the silica brick manufacturers have been put on their mettle, they have apparently got a better material or better processes, because in our new settings we have found exactly the opposite effect. We have had a slight settlement, probably due to the expansion joints or timber which we have put in. I would like to congratulate the author on his installation of Congdon standpipes. Our experience at Beckton is not in their favour; but I think I have said before that this is due to the length of the connection between the mouthpiece and the standpipe. The design shown by the author, I should think, would be an excellent one, and I am really very sorry it was not available some years ago when I recommended them. I should like to mention that the design which I showed in 1919 is hardly representative of the type they use in America. I was over there in 1920, and they certainly did not use that type of Congdon pipe then. It seems that I have used a very old one; and it is hardly fair to the American engineers to compare the new type with the old type. I do not think the author of the paper has said quite sufficient about the coke plant. Coke, as everybody knows, is troublesome to handle, and we should like a little more detail as to how the plant is designed. I have always been led to understand, and my experience has shown me, that telpher plants for an installation of the size of the author's are on the slow side. Perhaps he has arranged for two telpher drivers, or he may have some other means for speeding-up. Will the author give us the cycle of operations, and also some idea of the cost of handling the coke?

Mr. R. E. GIBSON (Liverpool): There are just two points I would like to mention. I congratulate Mr. Carr on the splendid results he has obtained with the use of slacks. At the same time, if we all went on to slacks I am afraid there would be no advantage in their use, because the price would probably go up to that of screened coal. Moreover, the throughput is bound to be reduced where slacks are used. The results at Stretford are very remarkable, and reflect great credit on Mr. Carr and his plant. I notice he has made special provision for the use of coke breeze in his producer. This may be suitable to the local conditions; but at Liverpool we have no coke breeze at all. We have plenty of coke, but no coke breeze; and therefore such furnaces as those at Stretford would be useless to us. I am sorry that this paper was not distributed before the meeting, because it puts one at a disadvantage in discussing it. The paper is full of interesting points which are worth careful study, and will undoubtedly help us very much in the future.

Mr. THOMAS HARDIE (Gas Light and Coke Company): I should like to add my thanks to those of the other speakers to Mr. Carr for his very interesting paper. The main point that struck me in listening to him was the extraordinary thoroughness with which he has studied the subject, and the care with which he has come to his decisions. He has considered all classes of carbonizing plant; and it is very interesting to-day to find an engineer who is prepared to consider all types. Many engineers seem to have got it into their heads that a certain type, whether it is one or the other, is their particular type under all conditions; and therefore I was very pleased that Mr. Carr examined so many types of plant before he came to a decision on the matter. I particularly wish to congratulate him upon using the Congdon pipe, and I wish to express appreciation of the thoroughness with which he has worked out the details of that piece of apparatus. The results he has obtained, I think, set us a new standard in horizontal retorts using slacks, and are such as we shall all be very anxious to reach. He has not explained it; but I think that the installation of the Congdon pipe is the possible explanation of these very fine results. The cooling of the gas as it leaves the retort, instead of it being brought up ascension pipes, has no doubt led to these important results. It has been an extremely valuable paper; and I am only sorry that Mr. Carr had to miss out any part in reading it. It is a pity we did not have the paper earlier, so that we could have discussed it more fully, though I feel that, from the thoroughness with which one can gather he has gone into the various details of the plant before he put it in, it would be rather dangerous to criticize merely on hearing it described this afternoon.

Dr. PARKER: I should like to ask if the author has experienced any difficulty in getting the pitch out of the connecting piece between the mouthpiece and the standpipe, in the case of the Congdon pipe. Then the author mentions 40,000 c.ft. of straight coal gas as being the equivalent of a ton of coke. Owing to the large amount of excess air required to burn straight coal gas and also to prevent the deposit of carbon on the regenerator tubes, I think the figure should be more than 40,000 c.ft. Finally, would the author tell us where the samples of gas were taken?

Mr. S. SHADBOLT (South Bank): I should like to congratulate the author on the thoroughness with which he has gone into this matter. Of course, the usefulness of these papers is largely found in their application to districts having similar circumstances to those of the author, and in the present case I imagine we must take it that considerations of the conservation of our coal supplies did not trouble Mr. Carr. There is a good deal in the point made by Mr. Gibson, that many of us cannot burn these slacks even if we could get them cheaply. Nevertheless, I think we shall all congratulate Mr. Carr on what he has done.

Mr. H. DAVIES (Chesterfield): As one representing a small gas-works, I must say that Mr. Carr's results are certainly extremely good. I have had the opportunity of installing similar plant to Mr. Carr's and operating it for the past six months; but I must confess that I have never been able to get the figures that he has mentioned in the paper. I should appreciate it if Mr. Carr would give me the privilege of going over the Stretford works and seeing how he does it. I am always willing to learn. With regard to the charge of 16 or 17 cwt. when using these retorts with slack, it seems to me that the charge is rather large, and must cause some difficulty in discharging. I should like to know whether the author has any difficulty in that respect, with consequent damage to the retort. With regard to the liquor, at 120° one must naturally expect some loss; and I should be glad to know whether this has been Mr. Carr's experience. He has only had four months' experience; but perhaps he will be able to give us some information on that point.

The PRESIDENT, in closing the discussion, said that, on account of the late hour, he would ask Mr. Carr to reply on the following morning.

Mr. CARR: I desire to thank you for the very kind way in which you have received my communication. Mr. Toogood, who opened the discussion, dealt generally with the matter of design; and one point which he emphasized—and with which I think we shall all be in agreement—was that, in order to ensure low fuel consumption, the producer in the first instance must be of large capacity, and that the regenerators cannot be too large. That, of course, was a factor which had an influence on the design of the settings, and, I believe, was a great factor in the results obtained up to now, so far as fuel consumption is concerned. Mr. Toogood also referred to one of the main objects being to bring as low as possible the net cost of coal. This was aimed at, of course, from the outset, and in the arrangements for gaseous heating the factor was that these arrangements should be available if residuals were a strong market. Of course, if coke is a weak market, obviously it pays to heat the settings with their own producers, utilizing the coke, rather than use gas from extraneous sources, whether it be producer gas or coal gas.

Mr. Collett asked if the retorts were 95 p.ct. silica throughout. That is so, and I think it is mentioned in the paper. With regard to liquor circulation, also mentioned by Mr. Collett and other speakers, the temperature of the liquor is admittedly high; and I might say in this connection that I think better results would be obtained if the liquor were cooled to a greater extent. In the other separating tanks which are now being put in, arrangements are being made to pass the feed water for the waste-heat boiler through a heater situated in the tank to serve a dual purpose—viz., to preheat the water for the waste-heat boilers and to cool the liquor. I think by this means it will be possible, instead of having a difference in temperature of the liquor leaving the standpipe—*i.e.*, till the point it is pumped from the separating tank—of 18° Fahr., we should get a difference of something like 35° or 40° Fahr., by cooling in the separating tanks. In that way we should get shock cooling to a greater extent than we do to-day, and a better scrubbing effect. No difficulty has been experienced in pumping the liquor at 170° or 180° Fahr. The pumps are of the ordinary Evans "Reliable" type; and though they have only been working for six months, they have shown, up to the present, no sign of deterioration. Mr. Collett also raised the very important point of the quenching of the coke on the floor. In my hurry yesterday I probably did not explain clearly what the arrangements really are. The way in which it is intended to deal with the

bulk of the coke is to pick it up with a high-speed telpher, and discharge it into a coke quenching bench situated outside the retort house, having done a preliminary quenching by hose as the coke is pushed-out from the retorts into the telpher skip. The telpher will not wait, but will simply discharge one skip and then return for the next skip. That is the intention; but this part of the scheme is at present only under construction, and at the moment we are quenching temporarily in a quenching tank, because in order to maintain the supply of gas the work had to be carried out in two stages. The first stage was the extension of nine beds, and the second stage the reconstruction of two beds of eight retorts in the existing house; and we cannot use the new coke arrangements until the reconstruction is finished, while the reconstruction could not be carried out until the nine beds are completed. The President has just referred me back, and asks what I mean by a high-speed telpher. The normal speed of a telpher depends, of course, entirely on the gearing of the motor; and when I speak of a high-speed telpher I speak of a machine which, given a clear run, hoists and travels at the same time, which was not so in the case of many of our old machines. As soon as the skip is lifted off the floor, and is quite clear, the travel commences. I am afraid I cannot say what the actual speed is, because I do not remember.

Mr. TOOGOOD: What is meant by a high-speed telpher is not only that the speed of the telpher is 500 ft. per minute or more, but that the construction of the quenching benches in connection with the telpher is quite novel inasmuch as the telpher will pick up the skip at the bench, take it straight away, put it on the quenching floor, and come back again. Therefore the whole time of disconnecting ropes is saved. Hence this is a high-speed telpher—about twice the speed of working of the usual telpher.

Mr. CARR: Thank you. The next point is with regard to dealing with the coke on the quenching bench. When the coke is discharged on to this, there is an automatic lifting bar; and on the return of the telpher for the second load of coke, the bar will be automatically lifted, and the coke will be discharged into the hoppers which supply the coke elevators. It has yet to be proved that the speed of operation will be adequate, having regard to the size of the house, with one telpher machine. The period within which we hope to complete the cycle into the house, discharging and back again, is 1 min. 20 sec. That is what we are aiming at; but I wish to make it clear that that is an estimate of what we hope to do, and is not a figure which we have achieved. A further question by Mr. Collett was as to the quality of the gas we are supplying. We supply 500 B.Th.U. gas at the moment, and it is our intention to declare that. We are diluting with water gas for this purpose; but it is possible that, when the whole of this extension is completed, we may declare a higher calorific value. That, again, depends largely upon the commercial circumstances at the particular period.

I am very pleased to hear from Mr. Leech's very kind remarks that he agrees with me that horizontal retorts were the right thing for Stretford. The section of the retort, 24 in. by 18 in., was chosen as being, in my opinion, the most suitable. We had retorts at Stretford 21 in. by 15 in. The old retorts were that size, and they were 20 ft. long; and so far as our short experience has gone, there is absolutely no comparison which could be made in results, because there are so many factors in the new plant which did not exist in the old. But I think with a simultaneous machine such as we have, as distinct from the projector type of machine, the 24 in. by 18 in. section is the most suitable; and dealing with Lancashire and Yorkshire coals, I venture to think it is the most suitable size, even for the projector type of machine. Mr. Leech said he could not give us the comparative figures for retorts of 21 in. by 15 in. section and retorts of 24 in. by 18 in. section. That is, of course, a difficult matter. If we had the two sections, both with standpipes, the figures would be very illuminating. One advantage of the standpipe is that it is a very simple matter to take samples of gas representing a period of carbonization when you have five retorts connected to the same standpipe. Another point raised by Mr. Leech was with regard to the free carbon in the tar. As long as the charges are maintained and the carbonizing period is not too drawn-out, we can keep it low. The free carbon in the tar is, of course, less when working on the eight-hour carbonizing period than it is with the twelve-hour period, when we have a higher temperature following the tailing-off in the last four hours of carbonization. Mr. Leech also raised the question of the coke plant, which I have already dealt with, except that I want to make it quite clear that the quenching tank is provided for use only in an emergency when the quenching bench or the mechanism in connection with it is out of operation. I want that to be clearly understood, because I think it is generally agreed among all gas engineers that immersion of coke is not at all desirable in any circumstances. I cannot reply to Mr. Leech's question as to the cost of handling coke, because the scheme is not yet completed.

Mr. Gibson mentioned the fact that we could not all use slacks, as the price would then probably go up to the price of screened coal. I appreciate that the price of slack would undoubtedly go up very considerably if it were extensively used by gas undertakings. At the same time, I do not quite agree with Mr. Gibson that it would go to the price of screened coal, because, after all, the kind of slack which is bought by myself, for instance, is from coal that is not being sold to gas-works, but is slack which is on the market from household fuels and other fuels. Mr. Gibson referred to the fact that the throughput was reduced if slacks are used. That, of course, is true in a measure. I would estimate the reduction in the throughput, using half-inch slacks as against large coal and nuts, as being approximately from 8 to 10 p.ct. Mr. Gibson also said that they were fortunate in Liverpool in having no coke breeze. This, again, I appreciate. When the coke leaves the retort house there is no breeze; but I would, with all respect, say to Mr. Gibson that, if he has a few thousand tons of coke in stock, there must be some coke breeze when that stock is moved. Even if he is making coke as hard as furnace coke, he will make some breeze when he moves the stock. There are times when we all of us must have some coke breeze; and the intention of the separate producer is not only to use coke breeze, but to use the cheap slacks containing up to 30 p.ct. of ash. There is a large quantity of slacks—almost colliery waste, you might call it—lying at the collieries to-day, which can be purchased very cheaply by those undertakings situated in the vicinity of the collieries; and this particular producer, with the super-imposed retort, is specially designed for the purpose of utilizing such slacks as producer fuel. These slacks can be bought, for instance, delivered at the Stretford works, at 7s. or 8s. per ton, and that is undoubtedly an economic factor. Even if coke is only worth 14s. a ton, and you can use cheap slack in your producer at 7s. or 8s. per ton, there is a great economy to be effected in heating. I refer, of course, entirely to the Stretford circumstances, and works similarly situated. To show it is being successfully done, I would refer you to the work with this super-imposed retort at the works of the Portland Cement Manufacturers at Swanscombe, and also to the experiments which I myself carried out at Preston. I have here a sample of the coke made in the passage through the retort of a Scotch washed fine at the works of the Associated Portland Cement Manufacturers. Here is a sample of the fine slack that was passed through, and here is a sample of the producer fuel that was made from it. This slack has a fairly high ash content—over 20 p.ct.—and the producer fuel was, as you will see, coked to a very good degree. The period of the passage of the slack through the super-imposed retort is not more than 40 or 50 minutes; and the temperature at which this coke is produced is approximately 500° to 550° Fahr. That is the average temperature in the retort. I explain it by two things—first, direct heat transference; and, secondly, the mechanical action of turning over the particles of coal in contact with the heat. It does, I submit, become a factor which is worthy of the consideration of those undertakings situated in close proximity to the coal supplies, where this very cheap coal can be obtained, of gasifying such cheap fuels for the purpose of heating the retorts, provided it can be successfully gasified. I should like to make it clear that on this matter I am now speaking of what has been done elsewhere, and of what I hope to do at the Stretford works.

Dr. Parker had asked if there was any difficulty in getting the pitch out of the connecting-piece between the mouthpiece and the standpipe. It is only 7 in. from the inside of the mouthpiece to the face of the valve; and the retort house lid-man has a small auger at an angle which he inserts into the opening of the valve, and moves up and down. There is no difficulty in getting them absolutely clear. The standpipes are arranged with the seal pots on the stage floor level, and are cleared out at each shift by the lid-man, who goes round and simply fishes to see if anything has been pushed through. We get about half a bucketful of mainly a mixture of carbon; but we have had no signs of pitch. It is a mixture of carbon and thick tar; but up to the present we have had no signs of pitch in the working of the standpipes. Another point which Dr. Parker raised was with regard to the figure I put forward of 40,000 c.ft. of straight coal gas as being approximately equal to a ton of coke; and he suggested that, with the excess air that would be required for the combustion of straight coal gas, and also to prevent the deposit of carbon on the regenerator tubes, a greater volume would be required. My estimate was made as the result of some investigations I was permitted to carry out owing to the facilities given me by the Chemical Company at Normanton, where they have been firing with coal gas for a considerable period, both preheated by regeneration and by admission direct into the producer arch below the combustion chamber. It was on the basis of the results of these investigations that I put forward this figure of 40,000 c.ft. I appreciate the difficulty which Dr. Parker mentions; and as a means of overcoming the question of carbon deposit, I think it will be probably necessary, on coal gas firing, to dilute with a certain proportion of either waste gas or, alternatively, with producer gas from external sources, because trouble has been experienced with straight coal gas firing through carbon deposit, as Dr. Parker rightly estimated. With regard to the samples of waste gas, these were taken at the end of the main flue, almost on the point of admission to the waste-heat boiler. The percentage of oxygen is low. We have had traces of CO in the gas, but only slight traces; and I put it down to the tightness and general efficiency of the new settings.

Mr. Shadbolt, in his remarks, suggested that the conservation of coal supplies was not a consideration of mine. I must rather

take exception to that. Possibly Mr. Shadbolt was looking at it from the point of view of gaseous therms; but there are, I suggest, two points of view. There is the point of view of maximum gaseous therms from a certain volume of coal, and the point of view of the maximum yield of both solid and gaseous therms. Both Mr. Shadbolt and myself—and, indeed, all of us—are aiming at getting the maximum yield; but Mr. Shadbolt takes the view that we will probably economize coal to a greater extent by getting the maximum yield in gaseous therms, and possibly I, being somewhat differently situated, do not quite see eye to eye with him. I will not delay the meeting now by giving the figures of the heat balance from which I showed an efficiency of carbonization of 82·04 p.ct.; but I will communicate them as part of the discussion. The only other point to be dealt with was that raised by Mr. Davies, of Chesterfield. I shall be very pleased to see him at Stretford, and show him what we are doing. With charges of 17 cwt. of dry coal evenly laid, we do not find the expansion on completion of coking has left a great amount of space at the top of the retort. We have had no trouble whatever in discharging; and I think that in these circumstances 17 cwt. charges are not excessive in 24 in. by 18 in. retorts.

The PRESIDENT: I am sure I voice the opinion of the meeting when I tender, on your behalf, our thanks to Mr. Carr for his very practical engineering paper. I feel specially indebted to him, because, when I approached him several months ago and asked him to write a paper on his new works at Stretford, he said he was very busy through having to meet a great increase in the demand for gas; but if it were my wish, as President, he would do it. He has fulfilled that promise to the utmost, and I personally thank him very much. On your behalf, too, I offer him our hearty thanks.

Mr. CARR: I thank you very much for the kind and patient way in which you have received the paper, and the reply to the discussion. I should like to say that I am indebted to the President in several ways. When the scheme first came under consideration of my Board at Stretford, another opinion was taken at my suggestion; and that "other opinion" was our President's. He supported the proposition I had put forward. I should also like to express my thanks to Mr. Toogood, who has co-operated with me in achieving what we have done—and I think we have realized some measure of success in this new setting. I should like to thank Mr. Ashley, of Messrs. Aldridge & Ranken, who assisted in carrying out various suggestions and modifications that we have made in the Congdon standpipe; while, finally, I should like to be permitted to express my thanks to my own staff, without whose help I could not have given this paper.

REPORTS RETAINED FOR PUBLICATION LATER.

This number of the "JOURNAL" is a complete record of the proceedings at the Annual Meeting of the Institution, in that an abstract of *all* the Papers and Discussions and the Verbatim Report of the sessions appear in it. We regret, however, that the unusual length of the contributions and discussions, coupled with postal restrictions, necessitates the holding-over of the following Reports: Wrought-Iron Tubing; Joint Refractories; Illumination Commission; and Gas Research Fellowship. It is our intention to include these as Supplements to our July numbers.

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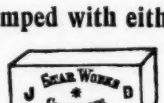
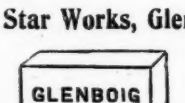
REGISTERED  TRADE  MARKS.

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DEVELOPMENTS IN GAS CALORIMETRY.

By Prof. C. V. BOYS, F.R.S.

Mr. C. F. BOTLEY (Vice-President) took the chair in the absence of the President—who was detained at the luncheon—and called upon Prof. Boys to give his paper. (The President arrived later.)

INTRODUCTORY.

Members of this Institution may remember that on a former occasion I gave an account of the progress which I had made in constructing a recording calorimeter; in fact, I showed this in action at the meeting. Subsequently I lectured on the same subject at the Royal Institution, and showed in action the instrument which I had constructed myself, and also one constructed by Messrs. John J. Griffin & Sons, Ltd. I showed also a "spot-test" calorimeter and meter, based on those of the recording instrument, and I indicated that this spot-test instrument promised advantages, especially in testing the gas of the smaller undertakings.

It was immediately after this that I first came in contact with that very remarkable material "onazote," or nitrogen-filled rubber, which is the most perfect non-conductor of heat known at the present time. The possibility of using this not only as non-conductor but also as water-containing material made into any form by the direct process of moulding, and so avoiding altogether the use of metal for this purpose, indicated such manifest advantages that, whether wisely or not, I determined that such advantages must be attained. I did not realize how long it would take to get a start on experimental construction. However, when the first "Block" calorimeters were made after inevitable difficulties had been overcome, their behaviour was so admirable that I felt the delay had been justified by the event. The Gas Referees had these under observation in their laboratory, and were satisfied; and then trials conducted in official testing places confirmed the accuracy and convenience of the new instrument. They found after a further lapse of time, however, that these instruments were beginning to give results which at first were almost imperceptibly in error, and which after a time showed increasing irregularity. After repeated attempts to cure this trouble had proved unavailing, I was driven after a loss of two years to abandon the use of onazote as a water-containing and insulating material, both for the recording and the spot-test instruments. If the inventor should succeed in overcoming the difficulty due to contact with water, its use might be considered again, but after this experience it would require the test of a year's service at least.

With disappointment and regret, therefore, I have had to go back to the form of calorimeter which I showed at the Royal Institution, and which it is convenient to distinguish as the "Box" calorimeter, and it is upon this and the consequent equipment suitable for small country places that I wish to speak more particularly to-day.

THE BOX CALORIMETER.

In carrying out their duties, the Gas Referees have been much oppressed by the cost and elaborate procedure which have grown up round the ordinary water-flow calorimeters, and which make their provision a burden which is serious in the case of small country places. This applies less to the equipment within the testing place than to the time required of the Gas Examiner and the tedious nature of the operation which he has to conduct.

It is with a view to reducing this burden that I have designed the complete equipment illustrated in fig. 1. In this it will be seen that the water required for the test is contained in a small tank standing on a stool on a table, and that the water, after passing through the calorimeter, is received in a similar tank below the table. For this reason it is unnecessary that water should be laid on or that a sink or drain should be provided, and the table may be made to stand in any convenient place to which the appropriate gas supply can be taken. The use of the same water over and over again, whether this water is distilled water, clean rain water, "tap" water, or boiled tap water, has certain advantages. While the gas in different places may differ, no trouble to the calorimeter arises on that account. On the other hand, the local water may differ, and the possible action of extra hard water on the one hand or peaty water on the other has been an anxiety rather than a material inconvenience. However, only recently the Gas Referees have met with a case where trouble has been caused by the fact that the water from the street mains appears to be a kind of soda water, and evolves so much gas as to interfere with continuous running of the present instrument, and to necessitate special measures. The re-use of the water not only removes the difficulties due to its doubtful quality, it also has the effect of causing the water to be very closely the same in temperature as the room in which it remains and the air used for combustion. A gas burner is provided below the upper tank, so that the water if too cold may be warmed.

Two other features of the water circulation are worthy of note. A hand pump is provided on the right-hand side of the table so that the water may be pumped back to the upper tank. The delivery pipe leads this water to the bottom of the tank, so that, by continuing the pumping operation, air is pumped into the water, and the stream of bubbles causes circulation of the water and uniformity of temperature. I have done away with the overflow funnel system for determining the water rate, and replaced it by a carburetter device derived from motor-car practice. When the main tap of the upper tank is turned on, the water runs into a down tube, with the usual perforated disc at the lower end. When, however, the water has reached a certain level, a float carrying a needle valve arrests the flow of entering water until it is just equal to that leaving the orifice below, so that the water is maintained at a constant head, and a constant flow is assured. The down tube can be moved to a back-stop, and then the water merely runs into the lower tank, or to a fore-stop, in which case it passes through the calorimeter. The water which has passed through the calorimeter leaves by a swivel outlet tube moving between stops. At one position of the tube it runs away to the lower tank, while at the other it is directed into a measuring flask like an ordinary litre flask, but with a divided neck, so that the amount run out while the meter drum makes (*e.g.*) four or five complete turns may be determined with great accuracy.

The water circulation within the instrument is very similar to that already described in my recording instrument, except that there are no operative thermometers, and the inlet and outlet thermometer ways are only $\frac{3}{4}$ in. in diameter. As in my recording instrument, the hot water leaving the hot thermometer tube passes through a helix of copper pipe round a cylindrical copper shield surrounding the calorimeter structure down to that level at which the water rising in the lead interchanger begins to change in temperature rapidly. By this means the insulation round the hot part of the instrument is relieved of the duty of preventing loss of heat to the casing which may be 10° or 20° C. cooler than itself, for it is surrounded by a shield of sensibly the same temperature. The insulating material which I have finally selected is compressed cork, such as is used for cold-storage insulation, round the interchanger, and granulated cork filling the wooden casing, well packed in and protected from access of moisture by means of an ebonite cover hermetically connected to the upper ends of the water passages in which the thermometers are placed.

Turning now to the gas circuit, the gas to be tested is brought from the service pipe to an efficient governor such as two governors in series, thence to a T, where one portion of gas passes away to a clearing burner, so that live gas may be tested, and not that only which is dormant in the service pipe. The other branch of the T leads through a micrometer tap to the Boys Bell Meter, and so to the burner. This consists of a narrow inner tube terminating within a plain parallel silica tube open above and below, which latter is held in a spring clip, and so can be moved down to be lighted and then be pushed up to its

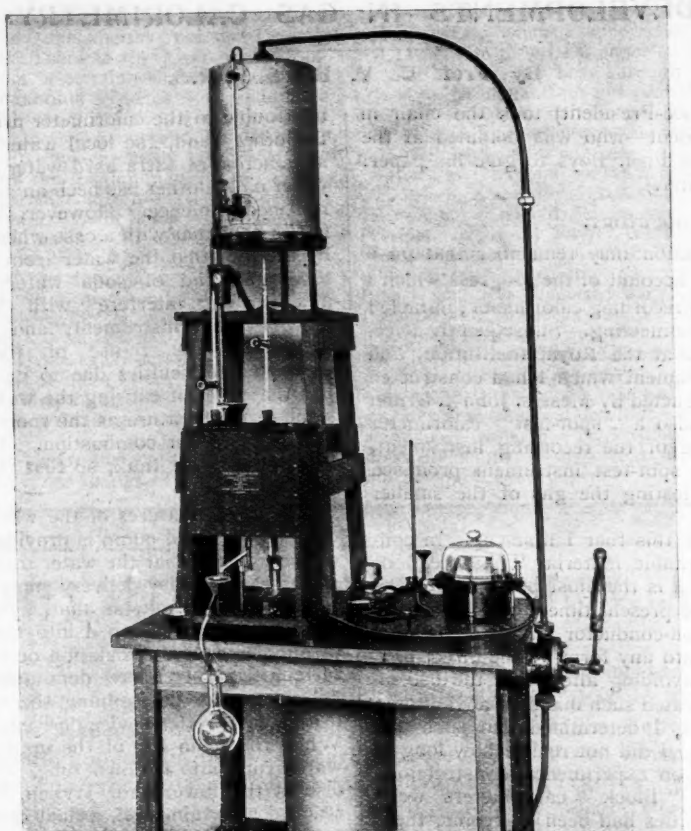

FIG. 1.

upper limit. This burner has the advantage that no moving gas connections are needed, and that the gas is somewhat aerated before combustion. It is, therefore, possible to burn as much as 1 c.ft. per hour without the formation of smoke or risk of imperfect combustion. The hot gases rise up to a silica dome and descend within the lead interchanger as in the recording instrument already described, and then entering an annular lead bowl are led down through the table, together with condensed water, by means of a lead duct. It is merely necessary for the Gas Examiner to find the position of the micrometer tap that will allow of the intended number of complete turns of the meter drum while the water is filling the flask up to some point in the neck, and this setting may be repeated with such small variation as may be convenient from day to day. As the exit water acquires its final temperature in a quarter of an hour, and the Gas Examiner has to make no adjustments of gas (after the first) or of water, and as, moreover, the tiresome process of proving the meter is unnecessary, it will be seen that the work of the Gas Examiner is curtailed and simplified.

I have so far described the Box calorimeter and its equipment merely as a calorimeter. The equipment, however, makes it possible for the table to be in itself a complete testing place. Then instead of a stool to carry the upper tank, a cupboard would be used in which the Gas Examiner could lock up all his books and papers. On the side of the cupboard there is room to fix the pressure gauge and the sulphuretted hydrogen apparatus, and a hinged flap in front would provide a convenient writing slope.

The Boys Bell Meter.

I have referred to the Boys Bell Meter, but a few words on this may be desirable. The ordinary test meter delivering one-twelfth of a cubic foot per revolution when in good order is a perfectly good instrument, but the Gas Referees have had much trouble in testing places, chiefly from "sticky" meters, that is those where from imperfect lubrication or other cause the friction in the stuffing box is both great and variable. They have also been troubled by small leakages developing in a surprising number of points of the meter, and also in badly made stoppered T's of the meter-proving measure. I have, therefore, wished to find some way of getting rid permanently of all these faults. When designing the recording calorimeter, the meter problem was forced upon me, and I believe the whole of these troubles have disappeared for ever in the meter I then designed. The chief peculiarity of the recorder meter was the use of a drum loose upon a screwed axle. The axle was turned at the required rate by clockwork, and the drum, relieved of all axle friction, was turned by the incoming gas. If the gas entered too fast, the drum turned faster than the axle, screwed itself along, and by so doing reduced the gas supply. The drum had no work to do except that of turning in the water, and thus the irregularity of gas flow consequent upon variations in gas pressure or friction were wholly eliminated. I am unable to use this feature in the Bell Meter as adopted for independent use, but I do retain the advantages of the original meter; for there is no stuffing box, but the axle moves in bearings in the water of the meter. (Fig. 2.) I still retain the buoyancy chamber which supports much of the weight of the drum, and besides forms a solid floor to the major part of each compartment at the critical moment at which a charge of gas is trapped within it. Leakage is impossible, as the drum is covered with a glass bell, making a joint with the bowl below the water level, and this allows the drum itself to be seen and its smooth working observed. Finally the water level is determined by the use of a submerged needle, which just disturbs or does not quite reach the surface of the water during the work-

Fig. 2.

ing of the meter. This level can be ascertained by reflection from the surface with far greater accuracy than any water line on a window can be read, and the actual level is made of less importance by the existence of the buoyancy chamber. In fact, this is its primary object. For these reasons this meter has great advantages both in accuracy, convenience, and, I believe, permanence over the usual form of meter. Provision is made for adding or subtracting water when setting the water level by the point, and the elimination of the operation of meter proving is itself an advantage. I used celluloid as the material with which to construct the drum, and its transparency is certainly an attraction. Messrs. Griffin are making the drums either of celluloid or of pure nickel. The capacity of the drum for the recorder and spot-test instrument is $\frac{1}{40}$th c.ft.

It would be almost too much to expect that where so much is gained from a radical change in design there should be no new fault or inconvenience. I know of only one inconvenience. Where the bell meter is left in a room which falls in temperature, especially if it is just below a window, the glass cools more than the water, and condensation occurs which in time completely obscures the view and makes observation impossible. This is best kept down as far as possible by covering the whole meter when not in use with a large protecting case. Any dew which may nevertheless be formed can be removed either by the application of a warm rubber water bottle made to fit over the bell, or simply by radiation from a luminous flame. If by either of these means the glass is warmed even a very few degrees, the water upon it will rapidly evaporate and condense on the water again. I have not yet been able to prevent the formation of dew by any coating within the glass, and I have not as yet cared to try the use of salts solutions with a smaller vapour tension, but that is a possible cure.

In a few cases where inconvenience had arisen from the necessity for frequently proving the usual meters and from other causes, a Bell Meter of $\frac{1}{12}$th c.ft. capacity has been substituted, and those in charge have approved the change.

Average Calorific Value of Gas.

Still confining my observations on this occasion to the needs and difficulties met with in the case of small undertakings, there is one for which up to the present the Gas Referees have not found a solution which can be considered altogether satisfactory. The difficulty is to find a value for the average calorific value of the gas supplied, when financial considerations unduly limit the number of tests. If the number of tests is too small, obviously there is a risk that the gas from a small works, of necessity more variable in quality than that to which most of us are accustomed, may be on the very few occasions of test caught at an unhappy moment when it is in a state of depression. Tests made at such times and unbalanced by tests made at more favourable times may give an unfair value for the average that has been actually delivered, and it is very little consolation to the Gas Manager to know that in the course of years the value must average out all right, if his undertaking is discredited on the unhappy occasions, and gets no credit for those in which he excels. It is not possible to remedy this hardship by increasing the number of tests indefinitely or even at all, because the cost of the tests becomes an item in the local rates, and the local authorities might refuse to make any test at all. As it is, it is only too often found that the limited number is considered excessive by the local authority. The result is that the number finally determined is a compromise, and like all compromises is not altogether satisfactory to any of the parties. The consequence is that the small gas-works have to provide gas which on the whole is of better value than that which they have declared if they wish to be safe from an adverse report.

It is to reduce this hardship that I have brought forward the simplified testing appliances and method described above. But that is not all. I now wish to indicate a further possibility—it is not more than that—that of obtaining a fair average value by a method of sampling, but here I am treading on delicate ground. Gas engineers know from experience that gas kept in their holders does not always retain its full value, and any system of testing gas that has been kept any length of time will be looked at with the gravest suspicion. All I now do is to ask you to remember that gas stored in holders and exposed to the cold at night may well have condensed out of it volatile and valuable constituents, and that such gas especially in cold weather may fall off in value. What I am now suggesting as a possibility is that in small country places the gas should be slowly and continuously drawn into a small holder in the testing place which is not exposed to the cold of the night sky, and that the Gas Examiner should make a test on the gas which, if there be no loss of quality, is an average of all that has been delivered since his last test. I am not saying that there is no loss of quality. I do not know, and in these matters it is unsound to assert that there can be no loss of quality because we do not know why there should be. That is a matter which can only be ascertained by direct experiment, and with all the different kinds of gas provided in the country it does not follow that the answer will be the same for all. Fortunately the gas engineers and gas chemists throughout the country are able to examine this question, and, in fact, without their help it would be impossible for the Gas Referees to examine every make of gas. With this explanation of the position, and remembering that what I am now putting forward is no more than a possibility which the Gas Referees could adopt only if found satisfactory and not otherwise, I think it desirable to explain the suggestion in more detail, and its many advantages to every interest concerned.

The sample of gas would be collected in a special gas-holder in the testing place, maintained if necessary at a uniform temperature. The gas from the service pipe would pass through a governor to a T where one branch would lead to a clearing burner, while the other would lead to the holder. The governor would reduce the pressure to a fraction above atmospheric. The gas would enter the balanced bell and lift it as fast as a clock over the bell would allow. The chain from the bell to a balance weight made as a sprocket chain would pass over a sprocket wheel connected by a clutch to a clock-turned axle, the clutch acting in such a direction that the bell could not rise faster than the clock allowed, whereas it is always free to descend when weighted. The clock would be so geared that the bell would fill in any pre-ordained time. In the example on which I have extemporized such a contrivance the bell fills in a week, but the time may be varied indefinitely. When a test is to be made, the incoming gas is cut off; the gas in the bell is led to the burner of the calorimeter, and the continued going of the clock has no influence on the outflow. The bell may then be weighted as desired. As a complete test may be made with the Box calorimeter in 25 minutes, and the gas is burned at 1 c.ft. or less per hour, a holder of very moderate dimensions only is needed. In the bell now before you, which was made by Messrs. Griffin & Sons, the annular space between the bell and the dumpling is as narrow as is consistent with free working, and the dumpling is above the water level. In consequence the gas is in contact with a very narrow ring of water only, the object being to make diffusion of soluble constituents of the gas as small as possible, so that when once the water has become saturated there should be no appreciable loss from this cause. The bell should not be filled so much as to leave less than say 2 in. of its edge immersed.

In taking the sample the question arises, what is the fair thing to do at night, say, for six hours, when the amount of gas passing in the mains is so very small. It does not seem fair to the gas undertaking to sample this equally with that passing in the busy hours of the day. One advantage of the clock sampling is that it lends itself to any system which in the future might be determined. For instance, a rough-and-ready plan would be to let the clock cause a detent to engage with the chain, say from midnight to 6 a.m., and stop taking in any gas at all for that period. Or, if it is considered better to take some account of night gas, the detent would be replaced by a slower moving tooth engaging with the sprocket chain or chain wheel, and the bell would take in gas at any reduced rate that might be desired. It is not necessary to show how any variation of rate could be produced. The mechanism is so simple that any proposition can be met.

There is one detail about the bell holder that should be mentioned, and that is the use of a sprocket chain of such weight that 1 in. of it weighs as much as $\frac{1}{16}$-in. length of the sides of the bell. Or, if that is too heavy to be convenient for the chain, then an additional idle chain passing over a pulley should make up this weight. By this means the change in the pressure of the gas caused by changing immersion and buoyancy is eliminated, and a governor between the bell and the burner becomes unnecessary.

Having now indicated, I hope sufficiently clearly, my proposal for obtaining a fair sample of the gas, I would ask you who have the control of small country works to consider it for the present as a kind of fairy tale which, if time and experiment should prove it to be true, should appeal to you as the work of a kind fairy. While you are doing your best with the manifest disadvantages which surround the manufacture of gas on a small scale, and while you are supplying gas which taken all round is all that you are required to supply, you are relieved from the unfortunate effect on your average of a test made at an unhappy moment, but are given credit for what you have done. And if any should be here who represent the consumer, and after all we are all consumers, then you equally are assured that a satisfactory test means that you have got what you have paid for, at least as far as the average goes. If it should all work out well, the more important object of the Gas Regulation Act would be attained, and this for the smallest place and at the minimum of cost. The consumer pays for value received and not merely for cubic feet of nebulous material. This test does not meet that other requirement of the Act—the 6 p.ct. two hours' minimum. This can be looked for as at present by a gas examiner whenever he tests, for he can examine the current gas as well as the stored gas.

Discussion.

The PRESIDENT: I think we are to be congratulated as an Institution in having as Gas Referees men like Prof. Boys, gentlemen of high scientific attainments who are not satisfied merely to administer the Gas Regulation Act, but who do all they can to help us to see that the gas we supply receives its full value. In Prof. Boys we have not only a scientist, but a gentleman of high mechanical attainments; and I desire to offer him on your behalf, not for his paper, because I do not regard it as a paper, but as a wonderful lecture, our very best thanks. When I asked Prof. Boys whether he would be good enough to give us a paper on gas calorimetry, he immediately said he would be pleased. Unfortunately, Prof. Boys, like myself, is not a young man, and he has not been very well; but we rejoice to see that he is able to come here this afternoon and give us this wonderful lecture. What we as an Institution and as the gas industry desire is that our gas shall be registered accurately, and Prof. Boys, by his invention, has been able to devise an instrument that can be placed in the hands of those in charge of the smaller works, so that they can see that the gas which they supply is of full value. This, of course, is most important for the smaller undertakings. The larger works can afford to have skilled chemists; but that is impossible in the case of the smaller works. And I am sure it will be to the benefit of the gas industry if we can place at the different works a recording calorimeter which will give us the exact value of the gas that is being supplied; and we want no more. My connection with the Gas Referees has been a most happy one. I find that they are not antagonistic to us; and while they carry out, as they are in duty bound, the regulations of the Gas Regulation Act, they are very anxious to assist us. By your large attendance this afternoon you indicate the interest you take; and I think it is a compliment to our friend the Professor that, notwithstanding the beautiful weather, you have turned up in such large numbers this afternoon. I, as your President, tender to Prof. Boys our grateful thanks not only for his lecture this afternoon, but for what he has done to help us in the measurement of the calorific value of our gas. [Loud applause.] Gas is now sold on the heat basis instead of on a volume basis; and, as one who has supported this from the first, I am very glad to know that most of the gas companies in the country are now selling their gas on this basis, because we know the value of gas lies in its heat value, and therefore it is most important, in view of the enactments with reference to the quality of gas, that we should receive full credit for the quality that we send out. I am therefore delighted to know that we are now likely to have a recording calorimeter that we can, with the utmost confidence, place in large works and small works, and know that the register we get is the accurate value as sent out during the whole 24 hours. If anyone would like to ask Prof. Boys any questions, I am certain he will be very pleased to answer them.

Mr. R. S. WHIPPLE (Cambridge Instrument Company): May I congratulate Prof. Boys on the beautiful invention he has brought before us? I feel that it is characterized, as all Prof. Boys' inventions are, by its absolute simplicity. He has dwelt a little bit on the difficulties of making a calorimeter; and if I may be allowed to say so, I, in a very much humbler sphere, know something also of the difficulties of evolving a satisfactory calorimeter. My colleagues and I at the Cambridge Scientific Instrument Company have been working for some time on a calorimeter, as Prof. Boys knows; and the time that passes away in some intangible manner in the experimental work does impress one very much indeed. You have to go on for a very long time before you can say that a particular calorimeter or a particular modification is a success. This, of course, is not only the experience of men making calorimeters, but it applies in many other directions also. I understand that in the case of Rolls-Royce cars, Mr. Royce has given definite instructions that no improvement or modification of any kind can be adopted on a car unless that improvement or modification has been tried for 10,000 miles on a car, and it is actually a fact that there are two or three Rolls-Royce cars running all the time in France trying-out improvements, because there are speed limits and police difficulties here which do not exist in France. This shows that even in engineering problems of that kind a great deal of time slips away. Prof. Boys has passed briefly over some of his difficulties; but I do not know whether it impressed you, as it did me, the way he has got over the radiation difficulty in the box calorimeter. I suppose he has used the analogy of the cascade electric furnace, where you heat outside in order that you may prevent radiation from the heat inside. I should like to ask whether he has thought at all of using kieselguhr as a heat-insulating material—that rather wonderful material which consists of some form of shell-fish or microscopic sea-shells, and which has the advantage that you have a large number of air spaces between the little pieces of shell, and I also think it is pretty independent of moisture. You can wet it without introducing very serious errors. Then, with regard to the gasometer, I think it is rather surprising that that has not been thought of before. For sampling the calorific value of coal, you take a little out of your various trucks, and lump them all together, and take a mean calorific value of the different samples; and it is really extraordinary that no one has thought of this extremely simple, yet very beautiful, invention of Prof. Boys, of having a gasometer which you simply fill up at a definite rate. I have no doubt that before long Prof. Boys will immerse the whole gasometer in a thermostatically-controlled water bath; and if he does so, I imagine that the difficulties of condensation and the other troubles he mentioned will practically disappear. I wonder if I might be allowed to tell you something which Prof. Boys has not mentioned, and that is that during the past twelve months he has received medals from two Societies for the invention of some of his instruments—viz., the Rumford Medal of the Royal Society, and the Duddell Medal from the Physical Society.

Prof. COBB: I do not know that I have anything to say concerning this address by Prof. Boys in any spirit excepting one of unqualified admiration and eulogy. It is always a great pleasure to hear a gifted experimentalist tell the story of his own experiment, an inventor to tell the story of how his invention has gradually evolved; and this, I think, is probably the main source of interest in what Prof. Boys has had to say this afternoon. When the Gas Regulation Act—or, rather, the original recommendations on which the Gas Regulation Act was based—was made by Sir George Beilby, I think that a number of us thought that this question of how the quality of gas for primary purposes was to receive continuous record had been treated rather lightly; but that it is an extremely complicated question you will have been able to gather from the examples which have been put before you so lucidly by Prof. Boys this afternoon, without indicating the high degree of complication which is really present in some of the questions which have received a comparatively simple solution under his expert treatment. As I say, they are really very complicated questions demanding the attention of a skilled and thoughtful

experimental physicist, and Prof. Boys is to be congratulated on his labours in that connection, and the gas industry is to be at least equally congratulated.

Dr. H. G. COLMAN: I have been exceedingly interested in this matter, and will just refer to one point on which Prof. Boys asked for information—not that I am able to give him any information beyond what he has said. Regarding the variation of the gas when stored in a holder of this sort, he said he thought no chemist would give a definite answer, though he himself did not see any reason why there should be be any loss until he had made further experiments. Some years ago I did make some experiments, but I am not yet able to say anything much more definite than Prof. Boys has said. When gas was stored in an arrangement such as Prof. Boys has here, in which the temperature is maintained reasonably constant, I was never able to find that there was any definite loss, to a greater extent, at any rate, than 1 p.ct. At the same time, the number of tests I made were quite insufficient to make it a definite proof; and further investigation under varying conditions of gas is required, and would be of very great value to the industry, and certainly to the small undertakings, though perhaps, also, to others; but it can only be done by a large number of people undertaking the work.

Mr. J. W. WOOD: It has been my good fortune, on behalf of the Institution of Gas Engineers, carefully to examine three calorimeters which have been proposed for use; and so far as one can see, all the instruments proposed had certain defects, but there seemed a reasonable chance of any one of them working, at any rate to a practical extent. I was rather unfortunate in not being present this afternoon during the whole of the meeting, and listening to Prof. Boys' remarks. As Prof. Cobb has said, it is extremely interesting to listen to the remarks of a man who has carried out the experiments himself, and knows what the difficulties are, not merely of devising a principle, but in carrying his apparatus to such an extent that he can obtain quantitative results within comparatively close limits. The apparatus we have seen to-day compels admiration in every respect. Naturally, in my position in examining calorimeters, I am rather interested in technical details, but there is only one small point on which I should like to ask Prof. Boys a question, and that is what provision has he with his gasholder for blowing-up the holder. Is there provision to keep the rate down if the pressure on the supply system goes up unduly; and what provision is made if for any reason the gas supply should fail? Dr. Colman made some remarks about the variation. As long as we are concerned with permanent gases or comparatively volatile vapours, I see no reason why we should expect any variation of gas in a holder of this kind, provided the bell is constructed of suitable material. On the other hand, there is just the possibility that, in certain circumstances, on the cooling of the bell, compounds will be thrown out which, either by polymerization or for any other reason, remain permanently there, and then dissolve the other constituents of the gas, leading to a permanent deterioration of the gas in the bell.

Dr. E. W. SMITH: I should be glad to know, if the calorimeter is to be available for small works—I expect it will be—and will enable the engineer to carry out tests accurately in a very short time, why it should not also be valuable to large works. Prof. Boys assumes that a large works has chemists; but these chemists are highly paid—or should be—and their time is valuable, and some of them could either be dispensed with to some extent, or they could be put on to more valuable work. Therefore, I should like Prof. Boys to tell us why he does not suggest that this instrument would be useful on large works as well as small. I have been wondering whether the engineers of small works who are not going to carry-out regular tests to check up the long sample will be prepared to wait until the end of the month or week to see what their test would be, or whether they should carry-out fraction tests, and correct them for what they now call a bad average, and put the matter right. As regards the use of the holder, Mr. Whipple perhaps does not know that in Birmingham and many other works it has been the custom for many years to sample the make of gas continuously like that in 100 or 200 c.ft. holders, but not by clockwork means. If Prof. Boys can tell us whether it is proposed to sample the gas that is sold, or the gas that is made, I should be glad. If the sample is to be taken on the make, that would be all right; but if the sample is to be taken on the gas as it leaves the works, then no amount of correction of speeds will account for the variations in output, apart from variations in quality and in the demand from the consumers. I am delighted with the address, and should like to congratulate Prof. Boys.

Dr. PARKER: There are a few points in this calorimeter on which I should like to make one or two observations. In connection with the sample holder, I understand that the lute which is sandwiched between the dumpling and the outer case is very narrow, and that this should cut down the solubility of the gases; but I should imagine that, if you take an average sample over a long period, you might alter the composition of the gas owing to solubility in the inner part of the channel, and the diffusion of gases, owing to a difference of partial pressure, into the surrounding atmosphere. I foresee some difficulty there. Whether it would go up or down in value, is rather difficult to say. Would it be too expensive in so narrow a channel to substitute mercury? It means having an iron gasholder instead of a tin one. Then, as regards the question of sampling in proportion to the rate of gas, Dr. Smith has raised the point whether it would be used for sampling the gas as made or as sent out to the district. In any case, perhaps, it would seem rather difficult to sample in strict accordance with a make which was fluctuating very considerably, unless the holder was geared to some main meter. In connection with some experimental work, we have the idea of sampling gas made at very different rates at different times, by gearing a small meter to the large main make meter. It may in some circumstances be possible to do this; but it depends upon Prof. Boys' idea as to where the instrument should be used.

Mr. T. F. E. RHEAD: I should like to ask Prof. Boys what will be the price of this instrument and whether it is possible to get it.

Mr. G. W. ANDERSON: Would the Gas Referees allow this apparatus to be used?

Prof. Boys, replying to the discussion, said: I have at any rate this satisfaction, that I have had no bricks thrown at my head metaphorically on this very drastic suggestion that gas should be sampled continuously. I did not know how that revolutionary proposal would be received, but, as I have said, it is no more than in the air. Mr. Whipple asked about the use of kieselguhr. I know that material quite well, but I have not tried it; at the same time, I do not myself think that as a non-conductor of heat it is better than compressed cork. So far as the moisture question is concerned, speaking as I did this afternoon, and depending upon the exuberance of my own verbosity, I naturally forgot to say many things that I intended to say. One of them was that the whole of the cork insulation inside the box type is absolutely removed from all possible contact with water. You might spill water on the calorimeter, but none would ever get anywhere near the cork. Thus the question of the cork being made damp does not arise. And, after all, if kieselguhr is made damp, I do not think it would insulate heat as well as if it were dry. Again, I forgot to say, in connection with this gasometer, that there is a sprocket chain which goes round a sprocket wheel. This wheel is not fastened to one of the clockwork wheels, but is connected by means of a clutch. I have used the same principle of a clutch which we had forty years ago in the old Cheylesmore tricycles, in which the wheel is free one way, but is instantaneously gripped the other way. In that case there were four rollers, one of which was always in a position to grip. I have made up something of the same kind here, and I have put in four $\frac{3}{16}$-in. steel balls, and one of them is always ready to grip, so that this bell can rise only so fast as the clock says it shall rise, and no faster. This answers the other question that was asked by Mr. Wood, as to the rate at which the bell rises with the gas fed into it from the holder through a governor. All this I forgot to say when I was speaking just now. Therefore, it is dealing with live gas, and not dead gas. This gas comes in at the pressure determined by the governor, and the clock determines the rate at which the bell rises. When the gas examiner comes along, and wants to test the gas, he pays no attention to anything else, but turns on the gas from the holder. The gas bell is weighted to $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$ in., or to anything you please; and when the gas examiner wants to test the gas, he does not interfere with the clock. The clock goes on ticking away, and this clutch device does not prevent the holder going down. The only thing the holder cannot do is to go up any faster than the clock says it shall; and it is the clutch arrangement which makes it so easy to adapt any device for altering the rate according to the scheme. I have said "according to the scheme," because I think that all methods of altering the rate according to the actual output from the works—and in large works you have several holders—is a hopeless proposition; and I think if, instead of having a hard and fast rule, we adopt some other rule which will fairly well meet the case, no one will be inclined to quarrel. We can say that from 6 to 12 in the morning we will take gas at a quarter the rate, or we can say we will not take it at all—that is a workable scheme. We can, of course, say that we will have all the gas-meters in the Gas Light and Coke Company's works connected-up with an epicyclic gear, so as to draw all their records together, and connect them electrically with all the testing places in London, but it is no use talking in that manner. It must be a workable scheme, and a practicable scheme, which fairly meets the case, and that is what I am suggesting now. You can, of course, suggest anything as complicated as you like. Dr. Smith has asked why this apparatus is not suitable for large works as well as small works. I do not remember saying it was not. I said I was addressing my remarks this afternoon specifically to the case of the small country works. As a matter of fact, I think it would be extremely useful in large works; and from what we have seen of this instrument at present I should very much prefer to use it instead of the standard Boys calorimeter, and use the whole equipment as you see it here. Though I did not say it, we

have been making very careful tests in the Gas Referees' Office. Our technical staff have been at work making a number of tests; and the results given by this apparatus and the Boys calorimeter are absolutely identical. There are slight variations from time to time, but on the whole the results are practically identical. I should very much prefer that the large works would use this instead of the old equipment. I think I have answered Dr. Smith's other question about sampling the gas leaving the works. Dr. Parker asked about mercury, and said this holder was made of tin; but it is not tin. It is either copper or brass tinned, and it is not what we usually call tin—viz., tinned steel. I have no use for things that do not last. Celluloid, as far as we know, is perennial; and this plated brass or copper holder is perennial in so far as it will not rust and break through. That, of course, would not be possible with mercury, and it would mean using steel or iron, which would be heavier. It would probably mean acetylene or oxy-acetylene gas welding, which now has become quite an easy operation. It could be done, but there would be a little expense in the mercury; and I do not know whether it is worth while. I did not catch the name of the gentleman who spoke about the soluble constituents in the water, and the division of these constituents down in the bell and up again, and evaporation into the air; but it was evidently put by a chemist of experience. If you give it long enough, this will take place; but at what rate it will occur with any gas I do not know. We have not got to the length of giving this a three months' test; but it may be of interest to you if I mention another thing which I also forgot—that the only gas which we have been able to test, the Gas Light and Coke Company's gas, in Victoria Street, has shown no change at all after a fortnight's test. I had hoped, when I got this holder last year, to have had, by this time, particulars of many tests of longer and shorter duration. We started with the old box calorimeter with onazote, but we could not use it with the Boys calorimeter, because it does not hold enough gas. Moreover, the accuracy of the tests when using onazote with the box calorimeter were not reliable, because onazote was found to be not perennial, and it is only recently that we have got the instrument that you see on the table. There was one other question, as to whether the instrument can be obtained. I must refer you to the makers as regards this. I am certain that the people who make these things do not make them for fun. I believe they want to sell them, but I have nothing to do with that part of the business.

The PRESIDENT: I will now ask you to accord Prof. Boys a hearty vote of thanks for his lecture, and can only express the hope that this calorimeter will be evolved soon in a form in which it can be used practically.

Prof. BOYS: I must thank you for receiving this paper in so favourable a manner. I may say that I began to have awful misgivings towards the end of last year, when, after the lapse of six solid months, I wondered what I was going to do, because the onazote on which I had built all my hopes was gradually fading away. I did not know what would be the end of it, and so the time had to come when I had to do something. So I cut adrift my ships and went back to where I was two years ago; and here we are. [Loud applause.]

The PRESIDENT: With reference to the Rumford Medal of the Royal Society which has been presented to Prof. Boys, I, as your President, when I saw the announcement of that award, wrote to Prof. Boys and congratulated him. I am sure this action will be endorsed by all present. [Applause.]

A Furnace Repair Gun.

For the purpose of re-lining, patching, or surfacing furnace walls with great speed and at low cost, the "Quigley Refractory Gun" is being marketed by the Quigley Furnace Specialties Company, of No. 26, Cortlandt Street, New York. It is operated by compressed air, and with it refractory materials of plastic consistency can readily be applied to places not easily reached by hand-patching methods. Pre-mixed refractory material is placed in the gun. The nozzle is then pointed at the place to be repaired, and the gun operator, by handling the valve controls, forces the mixture from the gun through a section of hose to the nozzle, where the repair man makes the application. The pressure required will vary from 50 to 100 lbs., according to the nature of the material. The gun consists of a cast-iron cylinder, from which the material is forced by pressure applied to the piston. The gun has a capacity of 2 c.ft. of mixed material, and is mounted on wheels, so as to be easily movable from place to place.

Gas Oil.—The "Petroleum Times" reports that, dating from the 3rd inst., the price of gas oil is reduced by ½d. per gallon to 5¼d., net and naked, *ex*-wharf.

Canadian Gas Association Convention.—A highly instructive and interesting programme of papers is announced by Mr. G. W. Allen (the Secretary-Treasurer) for the forthcoming annual convention of the Canadian Gas Association. This will take place in Quebec City, on July 15 and 16. The papers number 11 in all; and one of them is to deal with the subject of "Heating Vertical Retorts with Coal Gas."

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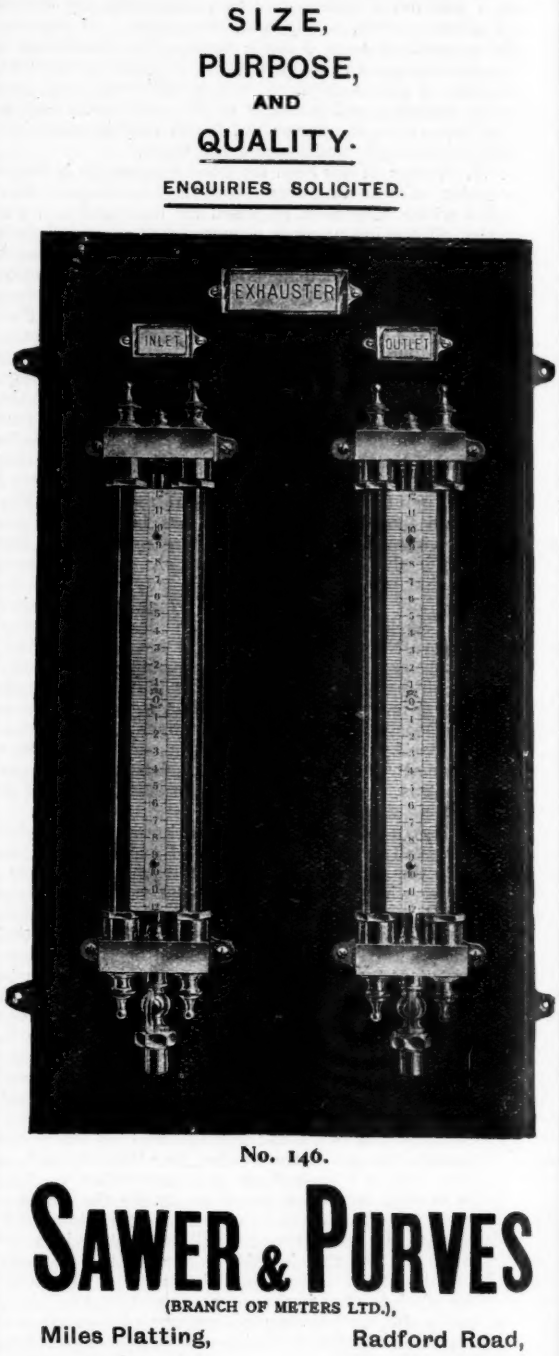

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NOTE ON TOWN GAS FOR MOTIVE POWER.

By SIR DUGALD CLERK, K.B.E., D.Sc, F.R.S.

Past President and Hon. Member of the Institution of Gas Engineers.

Town gas is by far the best fuel which has yet been produced for use in internal combustion engines. It is clean, it is uniform in its composition for each district, and its continued supply can be depended on; engines driven by it require a minimum of attendance and lubrication. Internal combustion engines of from 2 H.P. to 1000 H.P have used it successfully for many years. At present about 10 p.ct. of all the town gas manufactured and distributed in Great Britain and Ireland is used to produce motive power. The total power is approximately 360,000 brake horse, or about one-half of all the stationary internal combustion engines at work in our factories. The thermal efficiencies obtained are high; they vary from 25 to 30 p.ct. in the standard types of gas engines built by first-class makers. They are readily started, and can be relied on for long periods of service without breakdown of any kind. This is recognized by the small premiums required by the leading engine insurance companies.

Before the war the power of town-gas engines in use in all countries expanded rapidly. The war disturbed the trade, but now the industry is steadily recovering with the general slow recovery of the engineering and manufacturing industries of the world. The losses of war have, of course, impoverished all nations on this side of the Atlantic, so that our former customers abroad have too little money available to enable them to make their usual purchases from us. It is to our interest to trade with prosperous, not "poverty-stricken," nations, and we cannot expect to recover fully without the commercial recovery of other nations. It is our interest to help the recovery of our former rivals because they were also our former customers.

With the recovery of our overseas trade will follow that of our internal trade, and then the use of town gas for motive power will continue its war-interrupted increase. At present the balance of forces has been altered, and engineers are aiding recovery by the most rigid economy and economization of all available means of reducing the cost of motive power. Before the development of electricity, town gas enabled gas-engine builders to displace steam power up to about 100 B.H.P. At this power the lower price of heat evolved from coal burned directly in the boiler furnace balanced the higher-priced heat from gas notwithstanding the much higher thermal efficiency of the town-gas engine.

The pre-war cost of heat obtained from town gas varied from 2d. to 4d. per therm, while the heat direct from suitable coal was about 1d. per therm. The thermal efficiency of a small steam engine was never more than 5 p.ct., and that of a town gas engine never less than 20 p.ct., so that coal in a steam boiler would produce the same power from four therms which the internal combustion would produce from one. At about 100 B.H.P. a good steam engine will give about 8 p.ct. thermal efficiency, so that the fuel cost per B.H.P. falls below that of the gas engine. There is obviously a point when the fuel cost of gas for power exceeds that of steam due to the relatively rapid rise of efficiency with increase of steam-engine dimensions.

The gas-engine efficiency remains practically constant from 5 to 100 B.H.P., and this enables the smaller engines to work more economically than steam engines of similar power. Accordingly it is found that the great majority of town-gas engines at present in use are below the 100 H.P. limit. It is true that gas engines are run on town gas at powers of 150, 300, 450, and 1000 B.H.P. with complete engineering success, but the fuel cost is too great at the usual selling price of town gas to lead to general use in cities.

Many large engines are run on coke-oven gas for generating electricity for use at the pits, and many are used with blast-furnace gas which was formerly wasted or used most inefficiently under steam boilers.

Internal combustion engine builders are deeply indebted to the town-gas industry for the rapid development and success of their engines; they feel, as I have said, that no better fuel could be produced than good coal gas, and if it could be supplied at a sufficiently low cost per therm gas engines of every power would adopt it. At present, however, the price of 4d. to 6d. per therm is too high to compete with other sources of power above 100 B.H.P.

In order to develop a large engine trade it was necessary for engineers to attend to other means of obtaining motive power gas. This led to the invention and rise of the pressure and suction gas producer. In the suction form good anthracite and coke is completely converted into producer gas of from 130 to 160 B.Th.U. per c.ft. with a thermal efficiency of about 85 p.ct. The producer gas is admirably efficient in both large and small gas engines, and accordingly many thousands of horse power have been successfully operated within my personal experience at a cost for fuel less than that of coal gas. The producer, of course, adds to the cost of the power installation, and the attendance required costs more than that of a town-gas engine, but the total cost per H.P. hour is reduced.

Comparison of Cost by Town Gas and Suction Producer with Anthracite for 50 B.H.P. at 50 Hours Week.

Town gas at 2s. 6d. per 1000 c.ft. and 475 B.Th.U. net value, or 6·3d. per therm. Heat consumption per B.H.P. hour = 0·0975 therm.

Cost of Gas per Week.	Interest and Depreciation on £350 at 10 P.Ct. per Annum.	Water.	Lubricating Oil.	Labour.
£ s. d.	s. d.		s. d.	s. d.
6 8 0	13 5	*Nil*	5 0	10 0

Total cost per week, £7 16s. 5d.

Anthracite fuel (suction gas), 1 lb. of fuel per B.H.P. hour at 50s. per ton.

Cost of Anthracite per Week.	Interest and Depreciation on £570 at 10 P.Ct. per Annum.	Water, 2 Gallons per B.H.P. Hour at 6d. per 1000 Gallons.	Lubricating Oil.	Labour.
£ s. d.	£ s. d.	s. d.	s. d.	£ s. d.
2 15 0	1 1 11	2 6	5 0	1 2 6

Total cost per week, £5 7s. 8d.

When coke is used at 35s. per ton and a consumption of 1·25 lbs. per B.H.P. hour, the cost for the week falls to £5 3s. 2d.

A modern heavy-oil engine of the cold starting type calculated out on the same basis of a week of 50 hours and 50 B.H.P. developed during that time requires £4 18s. per week.

Diesel crude oil is to be used, and its cost is taken at £5 15s. per ton.

The total capital cost is £530, and at 10 p.ct. per annum this amounts to £1 0s. 4d. per week; in this case lubricating oil cost 5s. and labour 15s.

The costs stand thus:

	£ s. d.	d.	
Town gas	7 16 5,	or 0·75	per B.H.P. hour.
Anthracite suction gas . .	5 7 8,	,, 0·52	,, ,, ,,
Coke	5 3 2,	,, 0·49	,, ,, ,,
Diesel crude oil	4 18 0,	,, 0·47	,, ,, ,,

In the four cases the fuel costs alone are town gas, 0·61d. per B.H.P. hour; anthracite suction gas, 0·26d.; coke suction gas, 0·23d.; and Diesel crude oil, 0·51d. per B.H.P. hour.

In the case of electricity supply for power, allowing a motor efficiency of 90 p.ct., the current necessary to produce 1 B.H.P for each hour would require to be sold at 1·125d. per B.O.T. unit without making any allowance for interest on cost of electric motor, oil, or attendance. Some companies sell current for motive power at and near this low price—for example, Ashton-under-Lyne and Sheffield. To meet this competition it appears necessary to do everything possible to reduce the cost for power town gas to 4d. per therm. The demand for engines run by town gas would thus increase, and the gas consumption for power load would rise again as

before the war. In those times a considerable number of towns had reached the low figure of 2d. per therm; such towns as Widnes and Sheffield are good examples.

With the gas of that time 1s. per 1000 c.ft. equalled 2d. per therm and 2s. per 1000; a very common price was 4d. per therm.

In Sheffield now gas for power costs 6·4d. per therm. I do not suggest that the cost of town gas for motive power is the only element accounting for the reduction in the rate of increase; bad trade is largely responsible, but the price of gaseous fuel forms a large factor in determining the type of motor to be used. I have been long conscious of this fact, and I pointed out the importance of cheap town gas for motive power to the Gas Institute as far back as the Southampton meeting of 1902, and in 1905. I read a paper on "Coal Gas and its Rivals for Motive Power" to the North of England Gas Managers' Association. In this paper I discussed steam engines, gas engines, and electric motors, and the relative costs, and I then said:

"Even at present prices, in most towns, gas motive power is very much cheaper than electrical motive power." I could quote cases which have occurred in connection with the business of the National Gas Engine Company when electricity at 2d. per unit has been replaced by them by gas, with the result that the cost of power was reduced to about one-sixth, and this with gas at 1s. 9d. per 1000 c.ft.

There is no doubt whatever that both electric lighting and electric power companies are pressing hard to supply motive power; and a certain field will doubtless always be theirs. For powers up to 5 or 6 horse, occasionally used, no doubt they will find a considerable field: but if equal pressure were applied by gas companies, in conjunction with gas-engine manufacturers, I am convinced that the electric lighting companies would be prevented from seriously invading the field of larger powers. Even the very small gas-power trade might be held against the electric companies if gas companies would combine to let out gas engines on hire in the same way as they so commonly deal with gas stoves. The electric companies adopt similar methods; and there seem to be no good reasons why the gas companies should not fix gas engines in the same way as the Tyneside Supply Company, in Newcastle, fixes motors—either on simple hire or else on the five years' purchase system.

I am glad to find that our distinguished President has started a system at Derby whereby the rate of installing gas engines is increased. I wish him every success.

I agree with him in feeling that the increase of the town-gas power load is very desirable both from the point of view of the gas companies and the general public. We are more fortunate now in the greater liberty allowed by law to the great gas industry to vary the methods of manufacture and the composition of the gas produced so as to combine in one gas supply a thoroughly good gas for producing light, heat, and motive power at a low rate per therm supplied. The increased use of town gas will prove a great boon to the whole of our population both domestic and industrial. It is, of course, important to the nation to study and develop the supply of light and heavy oil for motive power and heating. Both light and heavy oil engines have come into very large use for locomotion on land, on sea, and in the air, but when we consider that the total heat of the oil raised from the wells in the world is only about 4 p.ct. of the heat of the coal raised from the pits, it is quite evident that coal and its products, solid, liquid, and gaseous, still remain of the greatest importance to the present and the future of mankind.

Internal combustion engineers are fully alive to this, and accordingly they study and test every type of fuel found in the world, and have adapted most of them, including waste products, to the purpose of producing motive power by their engines. They have accordingly designed special types of internal combustion engines for various liquid fuels, such as petrol, paraffin, heavy oils, and alcohol, and for gaseous fuels derived from many sources, first of all and most important town gas, then gases of the producer type from anthracite, coke, bituminous coal, lignite, peat, wood chips, sawdust, cocoanut shells. Such woody materials are often available in other countries where coal or coal gas is not to be had.

I look forward with interest to the more extensive use of town gas for internal combustion engines in settled countries of our type, and to the further discovery of useful carbonaceous matter in the wilder countries which can be dealt with in producer-gas engines.

At the conclusion of the paper, Sir Dugald Clerk said: I see nothing in the world to prevent town gas engines being used in all sizes. It is simply a matter of cost. We gas engine designers and constructors would never have gone to the other gases had we not been forced to do so by the necessity of getting some fuel unit that was rather cheaper than the coal gas then available. If we could return to anything like the 2d. per therm of pre-war times, you would have an enormous increase in business. I do not suppose you can do it; but, if you cannot, you may get down somewhat. Some of the companies are down to 4d. a therm now, but 6d. a therm is too much. It depends on yourselves; and if you really feel that you ought to get the power load to increase your consumption, it can only be done by keeping the price fairly low.

Discussion.

The PRESIDENT: We are much indebted to our friend, Sir Dugald Clerk, for bringing the question of town gas for power purposes so well before us, and for giving us the actual facts. I am particularly glad that I was able to persuade Sir Dugald, who we know is extremely busy, to give us this paper, because no one in the country knows more about internal combustion engines than he; and we are much indebted to him, and to the gas engine builders, for the enormous steps forward that they have made of late years in connection with gas engines. I have taken a great deal of interest in the supply of gas for motive power purposes, and it has paid my Company very well. It is over 20 years ago since I decided to let out gas engines on 3, 5, or 7 years' hire-purchase. We fix them complete for a certain fixed sum per quarter. We have now gone a step further; and I am glad to know that it meets with the approval of such a distinguished engineer and scientist as Sir Dugald Clerk—there is no reason why gas engines should not be supplied on simple hire. It is very important that, if we are going to foster the supply of gas for motive power purposes, we should not only fix the gas engine, but take care to have that engine regularly inspected and indicated, so that we can guarantee to power users that they have only to telephone to the gas office, and immediately one of our experts will be on the spot to make any slight adjustments, so that they can rely on the gas engine working continuously, there being no danger of stoppage. I believe we have lost, in the past, a certain number of customers through gas engines, from various causes, breaking down, and there being delay in getting them put right. In these days, when manufacturers keep their factories going on full time for 50 hours a week, it is very necessary that they should be able to depend on the motive power they are using; and there is no reason why gas engines should not be installed, and why manufacturers should not be satisfied that there will no danger of any breakdown. I ascertained from the insurance companies the ratios of breakdowns with electric motors, gas engines, and steam engines; but as the returns are a few years old, I do not think it fair to quote them. The returns that I got, however, showed that the ratio of breakdowns with gas engines was less than with electric motors or steam engines. There is no doubt that in oil engines, and especially with the present low price of oil, and also in electric motors, we have keen competitors. There are certain places where the power required is small and intermittent, in which the electric motor is very suitable, but there are a very large number of cases, where the power is comparatively regular, where the engine would be running from 48 to 50 hours a week, and where the power is from 10 to 100 H.P., in which you could quite well substitute gas engines. But, as Sir Dugald Clerk has pointed out, it is essential that we keep our price for gas down as low as possible. We know that the electric supply companies have captured the power business through charging extremely low rates. They charge something like one-fourth of what they charge for lighting, and in some cases considerably less than that. I am not suggesting that you should go to these extremes, but I do suggest to you that it will be worth your while to make a cut as far as possible, and reduce the price of gas for power, to encourage the increase of the power load. There is, of course, no better load for a gas company than a power load running for 50 hours a week, winter and summer. I am certain that one of the results of this admirable paper this morning will be that the engineers of all gas-works will pay more attention to the subject of town gas for motive power. At Derby we have a clever skilled mechanic whom we obtained from one of the gas engine makers, and he visits factories regularly, and canvasses for power; and the results are most encouraging. I am afraid, with the small undertakings, it would not be possible for them to have a well-equipped power department, as the larger undertakings can; but as I suggested in my Address, I think it is a

case where the larger companies can co-operate, so that their power departments will be at the disposal of the smaller adjacent companies, and by that means we shall be able not only to benefit ourselves, but to benefit the manufacturers. At the present time trade in this country is in a deplorable condition, and one of the results is that manufacturers generally are being compelled to look at their costs. If you can convince them that they can reduce their costs for power purposes by the use of gas engines, they will be willing to consider the question. If you say to them, "We will put your engine down, and we do not ask you to pay anything except a small charge per quarter for hire or hire-purchase," then I am certain it will be an inducement in many cases to go in for gas for power. I do hope that the members of the Institution will see that we do not lose our power business without a struggle, and that it is our intention, if possible, largely to increase the use of gas for motive power.

Mr. GEORGE HELPS (Nuneaton): There is an old saying that "the best goods are wrapped up in a small compass," and here we have an example. I am in the happy position of being able to endorse every word that is in this paper. I see the great significance of it. I admire the wonderful mildness with which Sir Dugald Clerk bids us look to our methods. He has put the case before us much better than anyone with a bee in his bonnet, like myself [laughter], could; nevertheless, he gets home. He tells us what the costs of power are with gas at 6d. a therm, and there is a difference, you will see, between that and oil, of round about 50 p.ct. You will see for yourselves what that difference amounts to if you are selling gas at 1s. a therm, as most of us are doing. Sir Dugald Clerk tells us that, to compete with this power proposition, we should be selling gas at 4d. a therm. I myself, a short while ago, lost business because I could not sell at 3d., and I lost it to oil. He also shows us the effect of complete gasification, and shows us that the thermal efficiency of the producer to which he refers is 85 p.ct. That is very different indeed from what you read earlier in the week in a table where it was shown that complete gasification gave an efficiency of 69 p.ct. I am only sorry that Sir Dugald Clerk has not translated these figures into costs per ton of coal, but I am certain the only reason is because of his great consideration for your feelings. [Loud laughter.] He knows that he can bear me out that, if we take 1 ton of coal, we get 70 therms, or 700 B.H.P. The electricity people are getting 1000 B.H.P., and we can get it by complete gasification. Sir Dugald Clerk even refers to 2000 B.H.P. I am not going to bore you by discussing all these things, but these are the figures you have to look to. However, you do not want to listen to me further, and, as I said at the beginning, good things are wrapped up in small parcels, and sometimes quite useful remarks are uttered in a short time. I thank you for listening to me.

Mr. P. D. WALMSLEY (Great Yarmouth): There is one aspect of competition between electricity and gas which I am up against in my town, and that is that in some industries manufacturers must have electricity. They require it for the purpose of their businesses, (say) the weaving and textile industries—a small motor on each machine, which gives them a superior finished article. Therefore, I should like to have seen in this paper the cost of generating electricity by a gas engine, and afterwards supplying it to these small motors, and at what price we should have to sell town gas to compete in that way. There is another point in the paper which I think is lost sight of in a great many instances in competition between gas and electricity. The electricity people, in our case, supply as low as 1¼d. per unit, whereas their actual generation costs alone at the generating station are 1·87d. per unit; and I would impress upon you the difficulties you are faced with when you are up against a proposition like that. The point is to ask their consumers what is the average price they pay, because many of them take electricity for lighting as well as power, and you will find that in many cases the charge for lighting is many times that for power. If you take the average costs to a consumer who takes electricity for lighting and power, I think you would find that in many instances it would pay the customer to put down a gas-engine electric generating set of his own. You should be able to convince many consumers that they can generate electricity by means of gas engines on their own premises cheaper than they can get it from a public electricity supply.

Mr. S. SHADBOLT (South Bank): The paper emphasizes perhaps better than many contributions we have had lately the absolute absurdity of the different methods of pricing gas and electricity; the absurdity being, of course, on the side of the electrical industry. The last speaker has given one instance, but coming, as I do, from the north-east coast, where we have super-power stations interlinked with systems of electrical distribution—which are, we venture to think, a great deal more to be feared than anything the Government is likely to promote—we find it is more acute still. In the general way, in active competition, we find that there is an unconscionable practice of absolutely fleecing the lighting consumer by the electric supply people, in order to under-cut the gas price to get power business. My own electrical competitor takes a bulk supply from one of the big north-east coast power companies; and not long ago a load came along in a pumping station for a water undertaking right outside my own gas-works. As a matter of fact, it was across the street, and the load was 100 B.H.P. for 8 hours a day. When the electrical people knew that I was after it, they went to the length of getting a special concession; and a special agreement was drawn up with their bulk supply people, which enabled them to cut the price to between 0·75d. and 0·9d. per unit. Yet the same people are charging 6d. per unit flat rate to all shopkeepers for lighting. We cannot compete with this, because I flatter myself that our industry has too much moral conscience, for one thing. On the other hand, one is sorry to have to admit that, though Sir Dugald Clerk rightly says it is a matter of cost when comparing forms of gas production—and cost alone, probably, for internal combustion engines—in electrical competition it is unfortunately with us a matter of cost and a good many other things when it comes to small loads, such as the convenience and adaptability of the individual drive. I am quite sure many like myself have found these to be more formidable points in competition than price.

Dr. E. W. SMITH: May I urge that gas engineers should not assume that the electrical industry is not moral because they adopt a system of the kind referred to by Mr. Shadbolt? I have been urging recently, and I do urge it at this meeting, that somebody, preferably the Institution of Gas Engineers, should start an inquiry in conjunction with accountants to consider what are the best commercial methods of selling gas. I am sure that a very good case can be put up for selling gas at 3d. or 4d. per therm at the present time by probably most gas undertakings. I am sure that it is absolutely uncommercial to sell gas for lighting at practically the same price as industrial gas, because domestic consumers are taking very small quantities, and there are high installation costs and so on. I do not need to go into that side of the thing at all, because it is one upon which we are all agreed; but there is no doubt that we shall lose a lot of business in the future, because the electrical undertakings are prepared to adopt systems by which the more the consumer uses the lower the price, to a very much greater extent than the gas industry is prepared to do. In such places as Manchester, where they have got what is known as the "Norwich" system—where electricity can be obtained for domestic purposes with a certain initial charge and at something like 1d. per unit afterwards—the fact that these people get away with it, and go on year after year, and make it pay, shows that they are not doing it for philanthropic purposes. They are not doing it to lose business, but they are doing it to gain business; and there is no question of immorality about it. It is business; and I do urge that an inquiry should be started to determine what are the practical means of differentiating between different charges for various purposes. I, personally, object to paying the top rate for gas when I use nothing but gas and coke in my own house, whereas the man next door, who uses no gas except a little for cooking, is charged the same rate.

Mr. S. SHADBOLT: The last speaker has reminded me that perhaps I allowed my feelings to carry me a shade further than I meant in using the word "moral." I meant that, when lighting consumers are over-charged, to subsidize power consumers who are directly under-charged, they are charged below the costs of generation, as has been proved. I consider, as a business proposition, that this is immoral. I was not alluding, of course, to high theology, or anything of that sort.

Mr. W. A. TOOKEY: It is needless for me to say that I have been extremely interested in Sir Dugald Clerk's admirable paper; but there is a saying that "fools step in where angels fear to tread," and I am going to dare to say that I think Sir Dugald Clerk has not been giving us quite a correct focus with regard to the rival methods of producing power. I think he will admit, when considering the figures of his table—I have only had the table a few minutes, and may be laying myself open to a retort which I shall thoroughly well deserve—that, particularly with regard to the production of producer gas from anthracite or coke, we can show for town gas a much better comparison, because the figures he has mentioned include no charges whatever for repairs or upkeep, so far as I read them. They include merely interest and depreciation on capital; but those of us who have had a considerable amount to do with suction gas producers will realize that the question of repairs should not be overlooked in comparisons of this sort. If this were not so, we should not find that so many users of suction gas plants, who adopted the fashion when it came in about 15 or 20 years ago, are now abandoning, in great number, these plants, and taking supplies of town gas, which they know is reliable and, all things considered, cheap. On the question of cheapness, I think that one cannot dissociate the question of service in connection with gas engines. I have been particularly interested in the President's remarks upon this point. I am not one of you gentlemen in the gas industry, as you know, but I am intimately connected with it, and I have first-hand information as to how town gas engines are working in various districts throughout the country. Only yesterday I was in a factory in London testing three small gas engines, each of them suffering from abnormal overloads; but, with all the difficulties of that kind, and the inefficiency which they meant, the owner told me that it paid him better to run these engines in that way to supply himself with electricity than to take a supply

of power from the public mains at the ordinary rates. Town gas has also been proved, in many districts in London, to pay in individual circumstances when proper accountancy methods have been adopted. Even kinemas find it very much better to make electricity from their own private generating plant, using gas engines; and there is always this advantage, that, apart from the convenience of town gas, there is the absence of stand-by losses, and the supply is ready at a moment's notice. There is also independence of industrial troubles from miners, railwaymen, and other people, because you have your eggs in your own basket, which is very much better than putting them in anybody else's; and this, of course, can be brought down to an £ s. d. factor of convenience *plus* cost. This is what I would recommend you gentlemen to study particularly. It would, of course, be inadvisable not to try to keep the charges for gas lower; but what I do, from my experience, offer to you as advice is that you should follow out the recommendations of your President this morning, and organize proper service for the engines working on gas. Then you will undoubtedly find your gas demand will go up, and particularly will it do so if you put the gas engine right down from the start, before the man has an opportunity to buy a second-hand gas engine from somebody else, which has already done useful service for a good many years, and has probably been erected by a man who is more like a plumber than an engineer.

The PRESIDENT: I am sure we are very pleased to have the remarks of Mr. Tookey; and I can endorse entirely what he says. In our case, if anybody wants to purchase a second-hand gas engine, we say that we do not recommend him to do it, and that it will pay him very much better to have a modern, up-to-date engine, because the saving in running costs and gas will be such that he will find it a better investment. With reference to Dr. Smith's remarks as to an inquiry concerning the selling prices of gas, that is a very difficult question; but I am certain that the British Commercial Gas Association will take notice of his remarks. If that Association can do anything to benefit the gas industry, he may be certain that they will do it. I may say that a number of gas companies, by their Acts of Parliament, are limited to a reduction of 25 p.ct., for power purposes, of their selling prices for lighting. This, no doubt, can be got over, because, fortunately, under the Gas Regulation Act we have more elasticity. If we are to maintain the business, and increase it, the great thing, as Sir Dugald Clerk has pointed out, and as Mr. Tookey has emphasized, is that we must give service and reliability. This is the first consideration. Manufacturers want to be able to start their works at 8 o'clock in the morning, and run continuously until 5 or 6 o'clock in the evening, without any chance of breakdown, for 300 days in the year. We say in Derby that the manufacturers can do this, and, if there is anything wrong with their engines, within a few minutes our expert is at their works, and does what is necessary. I have great pleasure in asking Sir Dugald Clerk to reply to the discussion. I am not surprised that there has not been more discussion, because the paper is so complete, and has been dealt with by a master in regard to internal combustion engines. As Mr. Tookey seemed to be afraid to venture, I can quite understand you other gentlemen also being afraid.

Sir DUGALD CLERK: With regard to Mr. Helps, I am very pleased to find myself for once in agreement with him. We seemed to have some considerable differences a few years ago when I was President of this Institution; but now I am glad that he and I are to some extent in agreement. I notice that he still adheres to the fallacy for which he then stood up—namely, in taking the efficiency of gas production you must count the 70 therms that you get in actual gas, and, as you know, a ton of coal has about 290 therms total heat. That infers that you have lost 220 therms, but, of course, you have not lost the 220 therms, and that is where we differ. I allowed for the coke and the tar, and all the other substances that come into combustion; but Mr. Helps does not.

Mr. HELPS: That is purely a question of economics, and you are putting the case from the economical point of view. The coke very often costs more than you get for it. That is my point, but I do not think we had better start an argument.

Sir DUGALD CLERK: I do not wish to irritate Mr. Helps, but I do not agree that you should not take the therms from the total coal, and the total distribution of heat, which I have given you. You all know exactly my views on that matter, so I will not go into it any further.

Mr. HELPS again rose and endeavoured to speak, but was greeted with loud cries of "Order."

Sir DUGALD CLERK, continuing his reply, said: Mr. Walmsley has referred to the question of electrical distribution, and I agree that this enables you to put down separate motors. This is an enormous convenience in some works, and it is so great that the National Gas Engine Company, of which I have the honour to be a Director, have a central electric station driven by gas, partly by coal gas and partly by producer gas, and from that central station we are distributing electricity all through the works for cranes and machines and everything. I think the remedy for the state of things which Mr. Walmsley refers to is that, if you can sell gas at a suitable price, it will pay to generate electricity on the works by means of gas-driven machines. I have noticed repeatedly that this question of charging for electricity for power purposes arises. The figure given by Mr. Walmsley of 1·87d. per unit is about the average for the country, and, as he says, electricity is often sold at a 1¼d. for power. On the north-east coast it is sold at a lower price than this, but I understand the station costs there are lower. If you take the very large new electric power station in Manchester, the Barton power station, the efficiency of generation was proved by the Government returns last year to be 20·33 p.ct. That is, you have 20·33 p.ct. of the whole of the heat of the coal in the electric current. In some of the stations on the north-east coast it approximates to that, and you can even exceed it with a higher load factor. With regard to Mr. Shadbolt's remarks, I quite agree it is a pity that lighting consumers should be penalized for the sake of the power consumers; and it would be better if this could be avoided. The same thing applies in this case, of course—that you can meet many difficulties of this character by generating electricity on the premises. Dr. Smith, I think, is accurate in saying that it is very desirable that accountants should go into the matter of the financial division between the gas lighting load and the power load. I think it would be found, as he says, that there is a certain distribution of power load which you can with advantage supply at a lower price, for the reason which your distinguished President said—namely, that you have a steady weekly or daily load, and in that way there should really be no loss. In that case the superior morality of the gas industry over the electric industry would not be shocked by a lower price for gas for power purposes. [Laughter.] Mr. Tookey says, no doubt from his own experience, that I have not added to the suction gas plant the cost of repairs. I may say that the figures I have given you have come from the works. Possibly they may be taking an optimistic view, but so far as I can see they have no reason to charge that 10 p.ct. for repairs, which is really a very heavy charge, and I think you will find that the repairs are not so high as Mr. Tookey imagines. These are works figures, but I will go into them again to please Mr. Tookey.

Mr. TOOKEY: I am not thinking so much of works figures as users' figures.

Sir DUGALD CLERK: I cannot be responsible for users' figures, because users sometimes give you very surprising figures which, on investigation, often turn out not so accurate. I can appreciate Mr. Tookey's point, which he makes from a large amount of first-hand information, because he has tested many thousands of gas engines in actual work, as to the value of service. There is the necessity to readjust the valves and other things, to bring the engines up to maximum efficiency. Of course, the more recent engines are far more efficient than the earlier ones; and it is better for users who intend to put in gas engines to put in new ones, and not second-hand engines. I agree with both Mr. Tookey and the President on that point.

Mr. GEORGE HELPS: May I have half a minute now?

Loud cries of "No."

Mr. HELPS: Thank you very much. Good morning, gentlemen. [Loud laughter.]

The PRESIDENT: I know you will agree with me in thanking Sir Dugald Clerk for his very valuable paper. About a month ago I had a communication from Sir Dugald, who informed me that he had to go to Italy in consequence of Lady Clerk not being well, and he has been there for several weeks. Upon his return he was engaged upon some very important cases that occupied an enormous amount of time, and he was afraid that he would not be able to give his communication. I pointed out to him that this Institution would be intensely disappointed if he was not able to give this paper ["Hear, hear"]; and he then said, if it was the wish of the Institution that he should give a paper, he would do so. Therefore, we are all the more indebted to him for his very valuable communication, and I have the greatest possible pleasure, as President of this Institution, in proposing a hearty vote of thanks to Sir Dugald Clerk.

Mr. H. D. MADDEN (Cardiff): It gives me the very greatest pleasure to second the vote of thanks to Sir Dugald Clerk. It is not the first time that we owe a great debt of gratitude to him. Some of his investigations are standard works to which we refer whenever we want to strengthen our case, either in the conservation of coal or as regards the production of electricity. The paper is one, I think, which we shall take away and think over, because there are many points in it which we shall require to study in regard to power production.

The vote of thanks was carried with acclamation.

Sir DUGALD CLERK: Mr. President and gentlemen, I thank you.

THE ECONOMICS OF GAS PRODUCTION ON THE THERMAL BASIS.

By GEORGE EVETTS, M.Inst.C.E., M.Cons.E.

The passing of the Gas Regulation Act, 1920, has enforced a new basis of comparison in gas production, distribution, and finance. The word "enforced" is used advisedly, as it must not be overlooked that for many years previously the thermal basis had been given serious consideration by many gas engineers, who realized that the volume basis was no longer the sound method of comparing either working or financial results. These pioneers voluntarily accepted the new standard of assessment, and new developments were viewed from the thermal standpoint. In fact, some companies promoted legislation whereby gas was sold with a defined minimum calorific value.

The Standard of Calorific Power Order made the procedure so simple that many undertakings accepted the calorific standard, which conferred substantial benefit on those who were in a position to take advantage of it, and whose candle-power standard was 14 or over.

These were only milestones on the road of progress, however; and it is clear now that the universal standard of 500 B.Th.U. or the special calorific value prescribed in the respective Acts of Parliament of the pioneers did not give the necessary elasticity to enable an undertaking to get down to rock bottom in costs of production and supply. Immediately the need for elasticity in manufacture became appreciated and recognized, it was apparent that the volume basis of sale must give way to the conception of selling thermal units in a more or less condensed form, leaving the strength to be settled by each individual supplier. There were some who preferred gas still sold on the volume basis at a guaranteed strength, using the standard therm price only as a medium for the calculation of dividends, but this method would have destroyed the element of simplicity which now exists.

The therm provides the universal standard of comparison; and as the gas industry is marketing therms, this is the basis to which all costs must ultimately be reduced. Calculations based on the volume of gas or the tonnage of coal are only useful in so far as they deal with the plant or machinery handling such volume or tonnage, and to this extent affect the working costs. Finally all results and costs must be reduced to the therm. This is sometimes lost sight of when considering (for example) claims of rival carbonizing systems. A motor-car maker only considers the amount of steel used or number of employees engaged so far as such information helps him to calculate the number of cars which can be made; but all his prices and comparisons must ultimately come down to the costs per car manufactured and sold. Therefore, the gas maker must first consider the known or likely demand for therms, and calculate his requirements accordingly. He cannot boost or retard this demand to any appreciable extent by ringing changes on the calorific value. If this were possible, then the freedom which the Act allows would be a fraud on the consumer.

Many discussions have taken place on the variation in the volumetric sale due to changes in calorific value, and somewhat remarkable statements have been made to the effect that chosen typical consumers have used the same volume, or even less, of low-grade gas, compared with corresponding periods when a higher grade was supplied. It is difficult to criticize these statements without full knowledge of the facts, but the author is of opinion that they would not bear investigation.

Tests on individual appliances have proved that, within fairly wide limits, the efficiency is approximately constant, or, to use the common expression, "one B.Th.U. is as good as another." Sometimes we are expected to believe that one cubic foot is as good as another. Now, what is true in the individual must be true in the aggregate; the author has made inquiries into the records of typical groups of consumers, and has found that the results are most conflicting. Therefore any theory could be promulgated by picking-out certain cases for quotation.

In dealing with upwards of ninety cases of applications for Section 1 Orders, the author has formed the opinion that, broadly, the volumetric consumption increases as the calorific value decreases. In one illuminating example, the calorific value was 540 (or thereabouts) in 1913, and 375 in 1921. The sale in the meantime had increased by over 50 p.ct. In other words, 540 therms sold in 1913 had risen to 565 in 1921, and the thermal sale per consumer was practically unaltered. The example formed a useful comparison, since there had been very little building work, no violent fluctuations due to munition work, and there is one staple industry on which the prosperity of the inhabitants depends. The position in this particular industry was unaltered, and, therefore, the comparison could be based on stable conditions. In the case quoted, the records of typical consumers were of no value in leading to definite conclusions.

The basis of all calculations, therefore, is the demand for thermal units; but, having got so far, the gas maker cannot dissociate the volume from his considerations. The volume of gas is the vehicle or medium by means of which the therms are carried, and a therm is intangible unless associated with the volume. The manufacturer of gas must produce a predetermined volume, and the distributor is called upon to propel this volume up to the point of ignition, with a certain flexibility at that point, but very little flexibility between that point and the gas-works.

To use the simile of whisky, if a distiller were permitted to choose any grade of liquor he wished, and sell on the basis of proof-spirit, he would, in preparing estimates of cost, find it necessary to take into consideration the size of the bottles and cases he would need to market the liquor, and the cost of transporting it to the homes of the consumer.

In the gas-works, the producer is given a large range in the carbonizing plant, both in volume and strength; but at this point the flexibility ends when considered on the volume basis. Exhausters, washers, scrubbers, purifiers, gasholders, and works mains are limited in regard to volume. Taking the gasholders as a case for comparison, assume that the maximum daily demand is 10,000 therms (1·82 million c.ft. of 550 gas), gasholder storage of 1,600,000 c.ft. would represent 8800 therms, or 88 p.ct. of the maximum day, with a 550 B.Th.U. declaration; but if the quality were lowered to 400, the thermal storage would be reduced to 6400 therms, or 64 p.ct. of the maximum. In order to reach 88 p.ct., as before, additional storage of 2400 therms, or 600,000 c.ft., would be necessary—costing about £15,000. This would add 1·4d. per therm to the capital cost per therm sold per annum (based on 250 maximum days per annum). The same would apply to a lesser extent to the other items of plant mentioned.

In the distribution plant the volume of gas to be handled would also be increased, with the added disadvantage that the specific gravity would be higher; and the combined effect might be that mains would need to be increased in size, with the result that additional capital charges would more than neutralize any saving effected in manufacture by the reduction in calorific value.

In matters of selling and administration, therefore, cubic feet can be discarded, but in manufacture, distribution, and measurement, the volume must be considered in conjunction with the heat units contained in that volume.

The following factors must influence the choice of the declared calorific value, whether it be the first or a subsequent change:

(1) The grade likely to give most satisfaction to the consumers; the special demands (if any) of trade and industry.

(2) The class or classes of coal available, and the relative prices delivered.

(3) The relative values of coal, oil, and residual products.

(4) The capacity, type, and condition of the carbonizing plant—viz., the efficiency.

(5) The capacity of the remaining portions of the works plant.

(6) The capacity and condition of the distribution plant.

(7) The latest developments in carbonizing plant and manufacturing processes.

(8) The operating costs of the various types of manufacturing plant, either existing or proposed.

(9) Capital costs and rate of interest on money in cases where new plant is under consideration.

Circumstances differ so widely that it is impossible to state the relative importance of the nine factors enumerated. Fortunately, a close financial estimate can be prepared of the effects of the governing factors except those numbered 1, 2, 3, and 7. In the case of items 2 and 3, a close estimate can be made of the conditions at the time of making the decision. Item 7 can be estimated with a reasonable degree of accuracy based on known results elsewhere or on makers' guarantees, leaving only the first, to which no numerical calculation can be attached. Past experience is usually the guide, and the combined skill of the purchasing, manufacturing, distributing, and selling staff is necessary to arrive at the right decision.

These nine factors will now be considered in order:

(1).—The Satisfaction of the Consumer.

The experience of the past few years has enabled many companies to gauge accurately the calorific value which is most acceptable to the consumers. It has frequently been observed that complaints begin and end within a comparatively narrow margin of calorific value. Whether these complaints are due to the insufficiency of the trunk mains, service pipes, or pipes on the consumers' premises is of some importance, for, if the change in calorific value necessitates wholesale alterations to mains and services, then a change is obviously undesirable. The same applies to the frequency of naphthalene troubles. If a change effected in the method of manufacture with a view to the alteration of calorific value seriously increases naphthalene trouble, it would be unwise to contemplate the change. As far as the appliances are concerned, it may be accepted as a general proposition that, if the pipe leading up to the appliance is capable of dealing with the necessary volume of gas having the proposed calorific value, then the adjustment of the appliance itself is a comparatively simple matter within wide limits. The nipple can be adjusted, and the pressure at the point of ignition can be increased or reduced, in accordance with the grade of gas supplied.

As previously mentioned, in deciding upon a calorific value it must be assumed that the demand in thermal units will be fixed, and independent of the grade; the efficiency of the appliances is constant within wide limits of value, and therefore no consideration of increased or decreased total sales should affect the decision.

The financial effect of this is to stabilize the standing charges per therm, whatever may be the declared value. It is necessary to emphasize this, as the author has heard it stated that, as the standing costs per 1000 c.ft. of gas are not affected by the quality, the richer the gas the lower the costs per therm. This would be true if the same volume of gas could be sold, but the increase in calorific value would automatically reduce the volume, and the costs per 1000 c.ft. sold would be higher before the conversion to costs per therm. In other words, the standing costs per 1000 c.ft. are affected by the quality.

It is equally important, however, to choose a value which will result in the thermal units being conveyed to the appliances of all consumers at the rate necessary for efficiency. The time element is as important to the domestic as to the industrial consumer. Complaints are made that the gas is bad, but the gas official knows that the real complaint is lack of pressure, preventing the consumer from getting the thermal units per minute or per hour which he wants. The result is doubly bad—the gas sales are curtailed and the consumer is dissatisfied.

From the experience gained during the past five or six years, there seems little doubt that the higher the value, within defined limits, the greater the satisfaction, assuming that the appliances are adjusted to deal with the gas without the dirt and waste indicated by carbonizing-up. Reducing the value *might* cause difficulties, but increasing it should not.

(2).—The Class of Coal Available.

The question of coal must be associated with the values of residual products and the type of the carbonizing plant—viz., items 3 and 4 in the list of factors.

If cheap coal is procurable from neighbouring coalfields, and the plant is capable of dealing with such coal, then the volatile matter and ash content compared with the price is a useful guide only if the coke yield is satisfactory in amount and quality. As the value of residual products gets less, so do the gas-producing qualities of the coal become of increasing importance.

To trace the effect of reduction of quality in coal or coke, take a simple case of two coals:

(*a*) Producing 63 therms per ton, and costing 28s. 6d.

(*b*) Producing 70 therms per ton, and costing 32s. 6d.

Now, if in each case the bye-products fetched 67 p.ct. of the coal cost, the net coals would be:

$$(a)\ \frac{33\text{ p.ct. of }28\text{s. }6\text{d.}}{63} = 1{\cdot}79\text{d. per therm.}$$

$$(b)\ \frac{33\text{ p.ct. of }32\text{s. }6\text{d.}}{70} = 1{\cdot}84\text{d. per therm.}$$

If, however, the coke from coal (*a*) fetched 2s. per ton less, the difference is 1s. per ton on net coals, and 67 p.ct. becomes reduced to 63½ p.ct., and the costs would be:

$$(a)\ \frac{36\tfrac{1}{2}\text{ p.ct. of }28\text{s. }6\text{d.}}{63} = 1{\cdot}99\text{d. per therm.}$$

$$(b) = 1{\cdot}84\text{d. as before.}$$

Therefore, the balance would change in favour of class (*b*).

If residuals produce a very large proportion of the coal cost, then the question of therms per ton is not so important, and a cheaper coal turning out less therms per ton might be more economical. For instance, if 20s. per ton of coal carbonized were to be obtained for residual products in the case of either of two coals, then a good coal at 30s. producing 70 therms would be less advantageous than poor coal at 26s. producing 60 therms.

$$\text{Net coal costs for good coal} = 10\text{s.} = \frac{120\text{d.}}{70} = 1{\cdot}71\text{d. per therm.}$$

$$\text{Net coal costs for poor coal} = 6\text{s.} = \frac{72\text{d.}}{60} = 1{\cdot}20\text{d. per therm.}$$

(3).—Relative Values of Coal, Oil, and Residual Products.

From the last few remarks it is clear that immediately coal quality comes under discussion it is impossible to keep clear of the effect of residual products.

After remaining stable for a couple of years, coke has unfortunately decreased in price substantially during the past twelve months. The receipts for tar and liquor also compare very unfavourably with 1923. The amount of tar and liquor produced per ton of coal is of comparatively minor importance in the cost of gas, though the prices received can be by no means neglected, seeing that the net receipts amount on the average to ¾d. per therm.

As Mr. Evans has pointed out in his Cantor Lectures, the thermal balance-sheet does not assume full importance unless the financial value of the therm in gas, coke, and tar is considered. To quote an absurdity, a process giving 95 p.ct. efficiency would be of practically no value if only 5 p.ct. of the yield was in the form of gas. In fact, a plant with 50 p.ct. efficiency, of which 25 p.ct. was gas, would be better financially.

The following may be said to represent fairly the value in the London district at the present time:

Coal at 32s. per ton = 1·28d. per therm.
Coke at 30s. per ton = 1·28d. per therm.
Tar at 3½d. per gallon = 2·00d. per therm.
Gas cost into holder = 4·50d. per therm.

On this basis, every therm produced as gas is nearly four times the value of a therm in coke, and over twice that in tar.

The following would represent the commercial value of a process per ton of coal handled:

$$\text{Value} = 4\tfrac{1}{2}\,t + 18\,c + 3\tfrac{1}{2}\,g$$

Where t therms of gas are produced at 4½d.,
c cwts. of coke are produced for sale at 1s. 6d.,
and g gallons of tar " " " " " 3½d.

This short cut would only apply, of course, where the same qualities of coal are dealt with at approximately the same prices.

In considering the value of residual products in relation to coal, the gas engineer is so familiar with net coal calculations that he knows the figure to which coke can drop before it pays to make water gas, and also the figure to which it can rise before he need seriously consider the question of dropping his "make" in order to have more residual products to put on the market. There may come a time when he must change his point of view, and regard himself as a producer of coke and tar. He could then afford to reduce his make per ton up to the point where

the plant would no longer deal with the tonnage of coal, or the market no longer absorb the residual products. The advantage under the Gas Regulation Act is that this lower make per ton would be richer, and consequently a higher value could be declared; and if this condition of affairs showed any prospect of permanence, it would pay to increase the declaration.

During 1921 the author, in dealing with a small undertaking making less than 20 million c.ft. per annum, found that the net coals were *nil*, due to a good local market for coke and tar, and it actually paid better (even on the volume basis) to make 10,000 c.ft. per ton rather than 12,000 c.ft. This would become more pronounced when selling gas on the thermal basis.

In cases where the residual products yield is stable in quantity, the financial result depends on residual prices; and the usual return from bye-products may vary from 50 to 80 p.ct. of the net coals, dependent on the selling prices. In these circumstances it is clear that, in the case of coal gas, the cheapest method of manufacture is that which produces the largest number of therms per ton of coal (leaving water-gas reactions or any steaming or similar combination out of the matter); and such method would cheapen costs in so far as the amount of solid fuel dealt with (coal and coke) is accordingly reduced.

In reference to coal gas manufacture without steaming, the decision is a simple one, whether the calorific value or the cost of manufacture is considered. The relative value of coal, oil, and residual products comes more into the picture when the steaming of vertical or horizontal retorts is under consideration, in contrast with the manufacture of water gas as a second-stage process.

It may be accepted without investigation that, in normal times (in fact, any time during the past five years), coal gas is cheaper than water gas, and a low-grade gas is more costly to produce per therm than a high-grade, if the lower grade is a result of water gas admixture, either blue or carburetted. In the case of steaming, the thermal increase is made at the expense of the coke yield, but at no cost for wages, very little for repairs, and only a small addition for fuel in the absence of waste-heat boilers.

In reference to complete gasification, the margin becomes very much narrower unless the financial yield from bye-products is uniformly good. Take, for example, a plant yielding 66 therms per ton with coal at 32s. and bye-products returning 80 p.ct. of this cost. The net coal cost is 6·4s. per ton, or 1·07d. per therm. A complete-gasification plant producing only a little tar and 180 therms per ton would result in a net coal cost of gas of 2d. (or thereabouts) per therm. However, if the yield from bye-products is reduced to 60 p.ct. of the cost of coal, then the complete-gasification plant would be cheaper.

With regard to the costs of water gas admixture, it is simple to construct graphs showing at a glance the point at which it pays to make water gas, either blue or carburetted. The economics of carburetting will be discussed later.

The relative value of coal and residuals does not seriously affect the costs of production between narrow limits of calorific value, but is material in considering the relative costs between high and low grade, where the latter includes the carbonization of the resultant coke, or complete gasification in one stage. It can be readily appreciated that, with relatively cheap coal and dear residuals, the high-grade gas is the cheaper to produce, and, with relatively dear coal and low residuals, the lower grades become cheaper, whether made as a result of complete gasification in one stage, or by steaming, or by producing water gas in a separate generator.

With any given price of coal, complete gasification will not pay (taking only net materials into consideration) if more than 60 p.ct. is returnable for residual products. This figure is based on the following assumptions:

1. That the fuel for carbonizing in one stage is paid for by the tar, &c., from the process.
2. That 180 therms per ton of coal are obtainable from complete gasification, and 70 therms from retorting.

180 represents 100 p.ct. of cost of coal.

70 represents 39 p.ct. of cost of coal (*i.e.*, net coals).

In the same way, it can be deduced that, with coke standing at or above 80 p.ct. of the price of coal per ton, it does not pay to make water gas, basing the make at 42,000 c.ft. per ton for generators and blowers. As a general rule water gas does not pay if 55 p.ct. or more of the cost of the coal is obtained from residuals.

It may be stated, therefore, that a low coke market should encourage the production of lower grades of gas.

Cost of Blue Gas and C.W. Gas.

At first view, carburetted water gas is much more costly than blue gas; but the net materials *plus* wages do not represent the total cost of these gases. Given a carburetted plant, it is cheaper to make carburetted gas; but if the gases can be made in separate plants, the respective efficiencies must be considered. The following table shows how the costs of blue and carburetted gas would compare if all factors are introduced. The coke figures and oil figures of yield are taken from Dr. Parker's paper on "The Production of Different Grades of Gas," read before the North British Association of Gas Managers, in September, 1924.

	Blue Water Gas. 840 C.Ft. 292 B.Th.U. = 2·45 Therms.			C.W. Gas. 1000 C.Ft. 483 B.Th.U. = 4·83 Therms.			Typical Coal Gas.
		Per 1000 C.Ft	Per Therm.		Per 1000 C.Ft.	Per Therm	Per Therm.
	d.	d.	d.	d.	d.	d.	Coals. d.
Coke, 36 lbs. at 30s. ton	5·8	6·91	2·37	5·8	5·8	1·20	5·00
Boiler fuel, 10 lbs. at 20s. ton (not necessary if waste-heat boilers)	1·1	1·31	0·45	1·1	1·1	0·23	..
Oil, 1·84 gallons at 5¾d.	..	..	..	10·6	10·6	2·19	..
Wages and salaries	3·0	3·57	1·22	3·0	3·0	0·62	0·80
Purification	0·3	0·36	0·12	0·5	0·5	0·10	0·11
Repairs to water gas plant	2·0	2·38	0·82	2·0	2·0	0·42	0·85
Repairs to general plant	3·4	4·05	1·39	4·0	4·0	0·83	0·85
	15·6	18·58	6·37	27·0	27·0	5·59	7·61
Less oil, tar, 0·2 gallons at 3d.	..	..	..	0·6	0·6	0·12	Residuals. 3·20
	15·6	18·58	6·37	26·4	26·4	5·47	4·41

Each gallon of oil adds $\frac{2·38}{1·84}$ therms = 1·29 therms.

In the above table it will be seen that, for an extra expenditure of 10·8d., we obtain 2·38 therms, or 4·53d. per therm, against 6·37d. per therm, as the original cost of blue gas.

Each penny reduction in the gallon of oil would reduce the cost of carburetted gas by 0·4d. per therm.

Each 2s. per ton in the value of coke accounts for 0·16d. per therm in the value of blue gas, or 0·08d. per therm in the oil gas; or 10s. per ton reduction in coke has only the same effect as 1d. per gallon in oil. The effect of 1d. per gallon drop in oil and 6s. per ton in coke would bring the coal gas equal in cost to C.W. gas, having regard to the increased cost of coal gas.

Therefore, if more therms are required from the combined plant, they are available in the water-gas plant, without one penny expenditure for capital, either in carbonizing or general plant, and at a cheaper rate than blue gas or gas very slightly carburetted. In the above table it is assumed that the additional thermal production is required, otherwise the fixed expenditure on wages would be divided over a smaller thermal output, and consequently be of no financial advantage. The table is also based on the assumption that the blue gas is made in a carburetted plant. If not, then the coke figures must be adjusted to the probable consumption. Such adjustments would only affect the difference; and it may be assumed that the cost of obtaining therms by carburetting will always be cheaper than the original blue gas. It is seen that, for carburetted gas, coke per therm is about half as much as for blue gas. The capital costs are not included in the table, otherwise the difference would become greater.

To sum-up briefly, therefore, it is safe to assume that, on present costs:

(*a*) Coal gas is cheaper than either blue or carburetted water gas.

(*b*) Carburetted water gas is cheaper than blue gas, into the gasholder.

(*c*) Complete gasification at 180 therms per ton is equivalent to coal gas when 60 p.ct. of the cost is obtained from residual products (after adjusting for fuel for carbonizing in the former).

(*d*) The cheapest coal gas to make is that giving the most therms per ton of coal in normal circumstances.
(*e*) The above factors tend to produce cheaper costs in higher declared values.
(*f*) Low coke prices tend to lower calorific values.

(4) and (5).—THE CAPACITY AND TYPE OF EXISTING PLANT.

As previously mentioned, the plant must be considered in conjunction with the prices of coal and residuals. A 100 p.ct. coal gas might be the right thing on paper; but if the coal gas plant is incapable of producing the full requirements, then the figures are only of value when considering the desirability of erecting additional plant for coal gas. The relative costs of the past two or three years have proved the desirability of having sufficient coal gas to meet total requirements. Everyone has not been in this fortunate position, but the lucky ones have been able to save at least the capital and sinking fund charges on water gas or extraneous plant used only in emergency. The emergency value of water gas must not be overlooked, and it is good practice and good economics to use retort houses or sections of retort houses to their fullest extent, producing thermal units with such labour engaged as is necessary and no more than necessary for the complete unit. Emergency demands or even seasonal demands of short duration can be met most cheaply by making water gas of value approximately equal to the coal gas.

The type and condition of the plant are generally the decisive factors in arriving at a decision on the nature and quality of the gas; but, in spite of this, there are comparatively wide limits of calorific value open for choice. Practically any known system has a variation of over 100 B.Th.U. per c.ft. The condition of the plant must be taken into consideration, but the performance in any set of conditions can usually be closely estimated by the responsible officer.

The maximum production of therms per ton is not always the cheapest method of production when everything is considered. One therm of gas is as valuable as $\frac{1}{6}$ to $\frac{1}{4}$ cwt. of coke, as it is produced at no increase in the labour costs, and very little for repairs. It is possible, therefore, that the maximum make of therms per retort in the house may be more economical than maximum therms per ton. The models prepared by Mr. Evans in his Cantor Lectures showed very clearly the thermal value of the gas produced at all stages of the distillation process, and it was obvious that the last two therms or so might easily be made at the expense of throughput or to the detriment of the ultimate cost of gas. When the volume only was of consequence, the additional gas appeared of more importance.

In a recent case in the author's experience, an undertaking was getting short of carbonizing power on the coal gas side, and water gas was more costly to manufacture. The problem was to increase the throughput of therms per day; and it was decided to face the consequence of reduced therms per ton. The duration was consequently changed from 12 to 8 hours, and the charges reduced by about one-fifth. It was anticipated that the make would be reduced by about 3 therms with an increase in coke for sale, due to the fact that the fuel required would not increase correspondingly with the coal throughput. The comparative figures of coal carbonized were:

Before the change, 2 per day × 12 cwt. = 24 cwt.
After the change, 3 per day × 10·5 cwt. = 31·5 cwt.
i.e., an increase of 31 p.ct.

The therms per ton dropped from 72 to 68½, but the coke increased from 10 to 10·6 cwt. for sale, as the fuel in the furnaces was not increased by more than 5 p.ct. The make per retort in therms, therefore, was increased from 1·2 × 72 = 86·4 therms to 1·575 × 68½ = 107·9 therms—an increase of 25 p.ct. After equalizing coal and residual prices, it was ascertained that there was a slight saving per therm on the repairs and wages, with the result that the gas into the holder cost 4·5d. per therm after the change, compared with 4·63d. per therm before. This is not a substantial saving; but the percentage of coal gas was increased from 75 to 87, and the total cost of the mixed gas is as follows, again adjusting prices to the same level:

Before.	After.
75 p.ct. coal gas at 4·63d. = 3·41d.	87 p.ct. at 4·50d. = 3·91d.
25 p.ct. water ,, at 6·07d. = 1·52d.	13 p.ct. at 6·07d. = 0·79d.
4·99d.	4·70d.

Hence the total over-all saving is 0·29d. per therm, and the increase in output has postponed for three years a capital expenditure of at least £25,000, representing 0·17d. per therm in interest and sinking fund over the whole output.

In another case the declared calorific value was 475 B.Th.U., and the quality actually made about 485. The maximum daily production was 1·9 millions, or 9125 therms on the made value; the annual make being 2,210,000 therms. The question of increased carbonizing power was under consideration, as well as a proposal to increase the calorific value, with the result that costs were closely investigated. The maximum working power of the retort houses was 7900 therms, with one empty arch for 8 through retorts for further development, leaving 1315 therms made in the water gas plant by 400,000 c.ft. of 340 B.Th.U. gas. Eight-hour charges were in operation, and it was ascertained that no further savings or increase of throughput could be obtained.

The next step was to ascertain the cost of increasing the calorific value by maintaining the thermal make of coal gas, but taking-up the increased sale by raising the declared value from 475 to 500, or the quality manufactured from 485 to 510.

The comparative figures worked out as follows:

—	A. 475 Declared. 485 Made.	B. 500 Declared. 510 Made.
	Therms.	Therms.
Annual make coal gas . . .	1,900,000	1,900,000
Annual make water gas . .	310,000	424,000
	2,210,000	2,324,000
Increase	[illegible]	5·2 p.ct.

The additional therms from water gas amount to 114,000, and the plant was capable of producing this without increased labour, by the addition of oil; and at 1¼ therms per gallon the cost was $\frac{114{,}000}{1\frac{1}{4}}$ × 6d. = £2280 per annum, or 4·8d. per therm made, which was less than the cost of the gas then being delivered to the holder. The over-all saving was estimated at £810 per annum. The actual increase in sale during the succeeding year was 5 p.ct., so that the additional bed of retorts was not required, but was set for the following winter, raising the coal gas power to 8500 therms per day. A further increase in the volume of water gas was contemplated, the cost per therm of which would be a little less than the water gas then being made. With a further slight increase in the calorific power of the water gas, the power of the works would be:

Coal gas	8,500 therms per maximum day
Water gas	2,750 ,, ,, ,, ,,
	11,250 ,, ,, ,, ,,
Compared with . . .	9,215 therms originally, or an
Increase of	22 p.ct. (say) four years' growth.

Since these estimates were made, however, the disparity between water gas and coal gas costs into holder has been increased, with the result that, if all coal gas could be made, the cost would be about 4·76d. per therm, and if made according to the above programme, the cost would be 4·97d. per therm—a difference of 0·21d. per therm.

The carbonizing plant proposed would obviously have to be built too large for immediate necessities, and the total cost would be approximately £22,500. The interest charge would be £1460 per annum, or 0·16d. per therm. So that, instead of producing a saving as originally anticipated, the increase as water gas is proving a little more costly, as the point has been passed where the increased thermal make can be effected by the mere addition of oil. However, the difference is even now only 0·05d. per therm more than the interest on the estimated capital expenditure, so that the programme has not been a failure.

If the existing plant were inefficient, and a new plant offered distinct advantages in efficiency and running costs, then a new factor would be taken into account; but this was not the case in the plant referred to.

With reference to the efficiency of carbonizing plants in general, they must be judged entirely on their merits according to known results and the proposals put forward by competing contractors; but it may be of interest to investigate the financial results of the methods of carbonizing summarized in Dr. Parker's paper to the North British

Table of Net Coal Costs.

No.	Method of Carbonizing.	C.V. of Gas. Gross.	Gas per Ton. Therms.	Coke for Sale. Cwt.	Tar. Gallons.	S/A. Lbs.	Net Coals per Therm. A.	Net Coals per Therm. B.
							d.	d.
1	Verticals, very light steaming	500	57	9·5	15	34	2·53	2·91
2	Verticals, steamed	400	93	6·7	20	42	1·82	2·02
	Extra 38 therms obtained for (per therm)						0·75	0·68
3	Verticals, no steaming	544	71·3	9·25	9·3	16·3	2·48	2·75
4	Verticals, 20 p.ct. steaming	460	103·8	7·5	12 4	21·2	1·89	2·04
	Extra 32·5 therms obtained for (per therm)						0·57	0·52
5	Horizontals	600	58	8·1	10·6	26	3·24	3·53
6	Horizontals and self-steaming B.W. gas	392	126	..	10·6	26	2·75	2 69
	Extra 68 therms obtained for (per therm)						2·15	1·97
7	C.W.G. plant, self-steaming	400	236 (1 ton coke, 59 gallons oil)	..	7	..	2·87	2·75
8	C.W.G. plant, self-steaming	500	336 (1 ton coke, 135 gallons oil)	..	16	..	3·25	3·17
	Extra 100 therms obtained for (per therm)						4·10	4·15
9	London Companies' horizontals	535	70·6	10·8	9·6	26	2 05	2·35
10	Verticals	470	82	9·4	14·0	28	1·83	2·11
11	Verticals	450	85·7	10 0	17·2	30·2	1·58	1·85
12	Tully, complete gasification	340	180 (1 ton coal, 3¼ cwt. coke and breeze)	..	12	..	2·13	2 15
13	Robinson, complete gasification	380	170 (1 ton coal + fuel for steam)	..	12	..	2·23	2·25

Lines 1, 2, 5, 6, relate to Dr. Parker's figures on Lanarkshire washed nuts.
Lines 7 and 8 relate to Dr. Parker's figures.
Lines 3 and 4 relate to Fuel Research Board results adapted (Mitchell Main nuts).
Lines 9 to 12 are from published results.

	Column A. s. d.	Column B. s. d.		Column A. s. d.	Column B. s. d.
Coal per ton	32 0 ..	32 0	Tar per gallon	0 3½ ..	0 3
Coke per ton	30 0 ..	27 6	S/A per lb. profit	0 0½ ..	0 0½

No.	Method of Carbonizing.	C.V. of Gas. Gross.	Gas per Ton. Therms.	Coke for Sale. Cwt.	Tar. Gallons.	S/A. Lbs.	Net Coals per Therm. A.	Net Coals per Therm. B.
							d.	d.
14	Parker, low temperature	700	39·6 (1 ton coal, 3¼ cwt. coke and breeze)	13·9	18·6	1·78 gallons spirit	1·41	2·06
15	Maclaurin, low temperature	250	68·5 (1 ton coal, 1 cwt. breeze)	11·0	15·6	17	1·42	1·77
16	Nielsen, low temperature	425	94·5 (1 ton coal, 1½ cwt. breeze)	7·5	20·0	..	1·61	1·81
17	Marshall-Easton, low temperature	466 to 403	71·5 to 103·0	9·0 to 6·0	18·0	28	1·27 to 1·50	1·59 to 1·67

Line 14 is taken from Fuel Research Board results.
Lines 15 to 17 are taken from results published by inventors.

	Column A. s. d.	Column B. s. d.		Column A. s. d.	Column B. s. d.
Coal per ton	32 0 ..	32 0	Tar per gallon	0 5 ..	0 4½
Semi-coke per ton	35 0 ..	32 6	S/A per lb. profit	0 0½ ..	0 0½

Association of Gas Managers previously referred to, as well as other systems.

Two bases are taken, the second showing a lower return for residual products.

The first eight items in this table should be used for making comparisons only within limits. The Lanarkshire washed nuts produce only 9670 c.ft. of 600 B.Th.U. gas, or 58 therms per ton, with 8·1 cwt. of coke for sale, when carbonized in horizontal retorts. It would appear either that this is an unsuitable coal for horizontals or that the horizontal retorts were not in a good condition, for when carbonized in vertical retorts 9·4 cwt. of coke were produced, with 67 therms of gas.

The unreliability of the thermal balance from the financial point of view, even when dealing with the same system and plant, is shown in comparing lines 1 and 2. The thermal balances of these two are almost equal, whereas line 2 produces gas about 30 p.ct. cheaper than line 1, due to the therms in the gas being of more value than the therms in the coke.

It will be seen that the extra therms produced by steaming are much cheaper than obtaining additional therms either in a blue water gas plant or by carburetting; in fact, the steaming of vertical retorts probably represents the cheapest method at present known of obtaining increased output. The figures are on the assumption that the coke from the steamed verticals is of the same value per ton as unsteamed.

The results for low-temperature systems show-up very favourably on the prices given; and if the yields can be guaranteed, coupled with a market value of 5s. per ton in excess of coke for the solid fuel, there are decided attractions in most systems. In the last four calculations, a small part of the solid fuel is taken at breeze prices. The tar is taken at 1½d. per gallon more than in the first part of the table, to include the additional value of spirit obtained. There is a substantial increase, however, in the cost of gas for 2s. 6d. decrease in the receipts for the semi-coke. It will be observed that in the Parker process it amounts to 0·53d. per therm, compared with half this amount in vertical or horizontal systems. Similarly a penny loss in tar per gallon amounts to 0·47d. per therm in the gas, compared with 0·15d. in the case of the existing methods. Thus 2s. 6d. a ton difference in coke (say, half this amount in breeze) and 1d. per gallon in tar affects the cost of gas as follows:

Parker process ... ... 0·73d. per therm.
Verticals with 20 p.ct. steaming ... 0·23d. per therm.

There is little to be added regarding the capacity of the works plant other than carbonizing. Practically the whole of the plant outside the retort house is limited in capacity on a basis of volume; and consequently the richer the gas the more economical will this part of the plant be to construct, operate, and maintain. Fortunately, the capital or running cost does not increase in proportion to the volumetric capacity, and it is real economy to construct plant well ahead of requirements.

(6).—The Capacity of the Distribution System.

Distribution problems in relation to calorific value have been fully discussed by able writers, so that only a brief note is necessary. Whatever may be the differences of opinion regarding methods of manufacture, there is no

doubt that the high-grade gas is favoured by the distribution engineer, for the following reasons:

1. Less pressure is required to deliver thermal units in a highly condensed form, due to the less volume to be dealt with. Alternatively, the same works pressure gives a better pressure to the consumer.
2. The lower volume is associated with a lower specific gravity.
3. The higher grade keeps the mains and services more free from corrosion, and therefore their carrying capacity is maintained.
4. The higher grade is usually associated with a higher saturation point, and naphthalene is less troublesome.

There is no doubt, therefore, that economically the higher grade scores on all points.

It is frequently argued that the distribution difficulties can be solved by increasing pressure at the works, but the fact remains that with a higher quality the increased pressure would deal with still more gas, so that a main of given size has a reserve of potential power if the calorific value is increased. Boosting gives rise to unequal pressures, and 12 in. near the works coupled with a bare 3 in. at the distant points cannot be desirable.

The increase of the minimum pressure prescribed by the Act of 1920 is only of practical importance in certain areas, as the gas undertaking previous to 1920 always aimed at a pressure in excess of 2 in. in the service pipes. In the areas affected, however, the problem is none the less a serious one, and the cure is usually a costly one.

The importance of the quality is clearly shown by taking typical cases. In a paper read before the Public Works and Transport Congress in 1923, Mr. H. E. Bloor compiled a comprehensive list of gases supplied by various undertakings; and the lowest in the range was 290 B.Th.U., and the highest 564 B.Th.U. Adopting Pole's formula, the pressure drop along an 18-in. main 3600 yards long delivering 500 therms per hour is shown in the following table, and the delivery in therms per hour with a fixed pressure drop of 2 in. is also given, together with the next lowest gas in the list (412 B.Th.U.).

B.Th.U. Gross per C.Ft.	Sp. Gr.	Pressure Drop at 500 Therms per Hour.	Delivery with 2 in. Pressure Drop, C.Ft. per Hour.	Delivery with 2-in. Pressure Drop, Therms per Hour.
290	0·59	180 tenths	57,000	166
412	0·62	95 tenths	55,700	229
564	0·40	33 tenths	69,200	390

No comment is necessary; the figures point the moral.

In connection with the supply mains in general, increasing attention is being paid to distribution holders at outlying centres of population. It is frequently found that the maximum hour is one-seventh of the day, and that 60 p.ct. of the gas is taken in six hours. The construction of outlying holders at balanced pressure results in working the mains for 24 hours a day (16 hours feeding and 8 hours supplying), with the result that their capacity is more than doubled.

Taking an example within the author's knowledge, an outlying village six miles from the gas-works, taking about 25 million c.ft. a year, has a maximum day of approximately 100,000 c.ft., and the pressure at peak hours drops to 25 or 30 tenths in the main street. The mains at the gas-works are 24 in. reducing to 18 in., and the last four miles are in 12 in., but the demand in the first two sections is naturally heavy.

A new holder of 70,000 c.ft. capacity is under construction, costing £4000, and ensuring a pressure of 48/10ths in the centre of the outlying supply, whatever may be the demand in the principal district. If the demand in the principal district increases by nearly 100 p.ct., the position in the outlying district is still secure. A 12-in. main would cost about £2700 a mile; and, therefore, the holder is put up at a cost of 1½ miles of main with no boosting expenditure. This does not represent the full advantage, however, for the increased holder storage reinforces the works storage to exactly the same extent, and provides for an increased business of nearly 25 millions. Therefore, the increased capacity of the main has been achieved at what is, in fact, very little additional cost, with the accompanying advantage of a constant pressure independent of what is happening in the populous part of the district.

(7).—Latest Development in Manufacturing Processes.

The newest methods of gas production do not actually call for detailed examination until additional plant is required. It is rare that any innovation offers such an overwhelming advantage as would justify scrapping comparatively new plant. Gradual replacement is always accompanied with improvement, and the "old-fashioned" systems are improved from time to time, with the result that, where new plant is necessary, the comparison is not between the existing plant and the latest innovation, but between the latest in all systems. Fortunately for the capital account, partial reconstruction, or even repairing, can be utilized for improvements in existing systems. The four main factors to be considered are:

(*a*) Net coal costs.
(*b*) Capital costs.
(*c*) Repair and maintenance costs, usually dependent on (*b*), since a low capital cost is generally associated with low renewals.
(*d*) Wages and operating costs.

During the past few years two methods of carbonizing have been developed for town gas manufacture—complete gasification and low-temperature carbonization.

Complete Gasification.

There is no doubt that complete gasification has come to stay. It is flexible, and the two systems previously referred to can be utilized to produce gas of considerable variation. In all the points mentioned above, the costs, when reduced to the thermal basis, are low. In general, it may be expected that any process giving a large thermal yield per ton of coal handled will produce low operating and repairs costs per therm; and this is intensified where there is no solid bye-product to handle.

Mr. Robinson, of Harrogate, gives the repairs for his plant at 0·11d. per therm, against 0·21d. for the horizontals; and the wages at 0·2d., against 0·4d. for horizontals, presumably compared on the same basis.

The wages on the Tully plant at Halifax are given as 0·55d. to 0·6d. per therm, including carbonizing and clinkering.

Low-Temperature Carbonization.

Low-temperature carbonization has yet to prove its claim as an accepted business proposition in gas-works; but there have been substantial improvements in recent years. It is obvious that the success of any system must depend primarily on the willingness of the public to purchase the resultant fuel at a price which compensates for the lower thermal production; and, secondly, the capital cost and working expenses must be reduced. The former of these secondary factors is more difficult of realization than the latter, having regard to the large amount of coal to be handled and distilled in relation to the thermal yield.

Contrasting extreme methods, complete gasification offers low capital with gas yields amounting to 140 to 180 therms per ton. Low temperature pure and simple is the reverse, as the constructional parts must deal with a heavy throughput with a yield of only 40 to 60 therms per ton, with no compensating speed of distillation.

For this reason the trend of modern invention is in the direction of admixtures with producer and water gas; and it would appear that success is likely to be achieved on these lines, using the heat as far as possible for internal carbonization.

If the public can be converted to the advantages of smokeless fuel, there will still remain the competition between gas coke at (say) 8s. per ton less than coal, and low-temperature coke up to 5s. per ton more than coal. Experience has taught low-temperature advocates that there is no advantage to be gained by carbonizing poor coals with high ash content.

At the Smoke Abatement Society's conference at Manchester in November, 1924, there were three papers dealing with the subject; and an analysis of the claims made will be of interest. The author has not been able to verify the figures given; but the financial results based on the stated yields should encourage further investigation, especially if the respective sponsors will guarantee their results. If any or all are ready with a genuine business proposition, they will find the gas industry willing to give the matter serious consideration. The industry already possesses to a great extent the market for the solid fuel, and provides the only substantial outlet for the resultant gas. The local

market both for coke and gas is essential to the success of the system; and though the large plants erected in thickly-populated districts near the coalfield form a valuable and substantial first step, the solution of the problem nationally lies in the scattered gas-works, where the dual demand is already developed.

The three processes referred to are:

(1) The Maclaurin plant, which gives a typical low-temperature gas diluted with a larger volume of water gas (formed from the steam admitted to cool the coke) and producer gas (formed by the admission of air saturated with water vapour), the latter supplying the heat of carbonization.

(2) The Nielsen plant, consisting of complete gasification in conjunction with low temperature, by means of which raw coal is used to improve the value of blue water gas (made from the solid residue of one stage in the process), by a double distillation. The process is, therefore, in three stages, which the inventor considers as the latest development for using his plant for the purpose of town gas supply. It is of interest to note that Mr. Nielsen considers that, to be financially sound, the capital cost should not exceed 10s. to 12s. per ton of coal distilled per annum, working 365 days a year, and that the working costs, including labour, fuel for carbonizing, repairs, and depreciation, must not exceed 4s. per ton.

(3) The "Coalite" plant, which is low-temperature carbonization pure and simple in a single stage, presumably distilled by producer gas, or at any rate by a fuel produced outside, keeping all the solid residue for the outside market.

A fourth process is the Marshall-Easton system, which consists of a water gas generator coupled with twin vertical retorts. The special feature of the twin vertical retort is that in each retort there is a hollow shaft and a twin screw or helix mounted on each shaft. These screws revolve at a predetermined rate, with the result that the coal is lowered through the retorts at a fixed rate, and the layer of coal is never more than 4½ in. thick. Any desired percentage of the low-temperature coke can be used in the water-gas producer. The potential sensible heat of the blow gases is used for carbonizing the coal at low temperature, and waste-heat boilers are incorporated for steam raising. The blue water gas made is passed through the coal during the process of carbonizing.

It would appear that, unless a substantial proportion of the coke is gasified in a generator, there would not be sufficient heat for carbonization of the coal, without outside assistance.

The following table shows the results given, and the financial return, when taking coal at 32s. per ton, the solid fuel at 35s. per ton, oils at 5d. per gallon after deducting the recovery costs, and sulphate at £4 13s. 4d. per ton profit. The capital is calculated from the only figures available on a basis of 240 maximum days per year; and the author has made certain adjustments, in order to draw a comparison between the four systems and the gas-works method, where usually the "coke for sale" is after providing fuel for distillation, as well as works boilers, &c. It is difficult to get exact comparisons, as the coals treated are not the same in all cases.

—	Maclaurin.	Nielsen.	Parker (Coalite).	Marshall-Easton.
Capital cost per ton of coal per annum	34s.	19s. 6d.	37s.	18s.
Do. per therm per annum	5·96d.	2·48d.	11·21d.	3·21d.
Gas per ton	27,400 × 250	22,250 × 425	5,600 × 705	15,320 × 460
Therms per ton	68·5	94·5	39 6	71·5
Net coal cost per therm.	1·42d.	1·61d.	1·41d.	1·27d.
Labour and supervision per therm	0·27d.	about 0·25d.	..	0·25d.
Repairs per therm	0·36d.	about 0·30d.	..	0·25d.

(8).—Operating Costs.

Under this heading are included wages, fuel or power costs, and repairs. All are important; and it is possible for an increase in wages to counterbalance a saving in net coals when comparing two systems, and frequently a particular plant may be chosen on account of low wages and repairs together.

Wages.—Dealing with wages first, it is difficult to lay down any hard and fast rule, as the scale of operation differs in almost every case, and the cost is dependent on the full or partial employment of the plant. Minor variations in the value of coal gas cannot be said to influence the wages costs per therm. Generally speaking, it may be accepted that the expenditure in wages is more a function of the amount of coal handled and the number of charges, than of the thermal yield. In machine charging, the number of charges is of more importance than the weight of the charge. At the same time, certain general rules regarding wages can be followed respecting the type of carbonizing, among which are the following.

(*a*) Vertical retorts are cheaper to operate per therm than horizontals.

(*b*) The additional therms obtained from steaming are gained at less cost per therm than the straight coal gas, thus reducing the cost of the whole; and this would apply even with steam generated in an outside plant.

(*c*) Water gas is cheaper (even per therm) than coal gas of the same size output, if each plant is operated to the same proportion of its maximum production.

(*d*) The additional therms obtained by carburetting are obtained for practically no increase in wages, thus reducing the overall wages cost per therm.

(*e*) Wages in complete gasification systems should be the lowest of all, if the plant is properly designed and in proper working order.

(*f*) A decrease in the carbonizing period for horizontal retorts will lead to increased wages per therm, unless there is sufficient elasticity in the arrangement of shifts, or the increase in therms per retort compensates for the more frequent charging.

(*g*) As a general rule, the less the amount of solid fuel handled per therm, the lower should be the expenditure on wages.

Consider for a moment the last of these rules in relation to the manufacture of gas in horizontal retorts and complete gasification, and examine the amount of solid fuel handled per 100 therms.

Horizontal Retorts—		
To retorts (coal)	20 cwt.	
From retorts to producers (coke)	2¾ ,,	
From retorts to dump (coke and breeze)	11¼ ,,	
	34 cwt.	
For 70 therms—*i.e.*, for 100 therms	48·6 cwt.	(1)
Resultant coke gasified (assuming the above handling of coke suffices to deliver it to the water-gas plant).		
Additional fuel to boiler, say	1½ cwt.	
carbonizing in the plant the remaining 9¾ cwt.		
Total	35½ cwt.	
Therms in resultant water gas = 24,000 c.ft. × 300 = 72.		
Total, 142 from 1 ton of coal originally—*i.e.*, per 100 therms	25·0 cwt.	(2)
If second handling required for water-gas coke	31·9 cwt.	(3)
Complete Gasification (One Stage)—		
To plant	20 cwt.	
To boilers	3¼ ,,	
For 180 therms	23¼ cwt.	
i.e., for 100 therms.	12·9 cwt.	(4)

It is clear, therefore, that double-stage complete gasification is certain to result in lower wages per therm than horizontal retorts alone, and that complete gasification in one stage must be less than either. The above proportion would not hold good, but the difference should be substantial.

It is difficult to get actual wages comparisons, owing to the different methods of allocation in existence. Taking "Field's Analysis" for 1924, the lowest is 0·274d. per therm for Leicester, and the highest 0·875d. per therm for Bradford. It is probable that items are omitted in Leicester which are included in Bradford.

With regard to the comparative costs of wages for coal gas and carburetted water gas, in the same publication the figure for water gas amounts to 0·45d. per therm, and coal gas amounts to 0·55d. per therm or thereabouts.

The following are recently published figures for carboniz-

ing wages per therm made, though they may not all be compiled on the same basis :

	d.
Verticals at Glasgow	0·38
Verticals at Glasgow	0·39
Verticals at Coventry	0·27
Horizontals at Coventry	0·41
Tully gas at Halifax	0·55
Horizontals at South Metropolitan, 1924	0·52
Horizontals at Newcastle	0·40
Robinson's plant at Harrogate	0·20
Horizontals at Harrogate	0·40
Low Temperature (Maclaurin's estimate)	0·27
Eastbourne, horizontals—machine-charged	0·58
Welwyn, hand-charged retorts	0·99
Pinner, hand-charged retorts	0·90
Pinner, water gas lightly carburetted	0·75

The above figures are comparable when dealing with the same works, but, as before mentioned, the expenditure in the printed accounts conveys no evidence that one method of carbonizing or one quality of gas offers overwhelming advantages in wages expenditure.

In the case of water gas, the wages per therm decrease as the amount of carburetting increases; further, the wages increase as the plant is used at a lower percentage of its maximum.

In machine charging, the therms made per charge are of primary importance. Hence the reduction in wages which can be effected by changing from 8 to 12 hour charges while retaining 8-hour shifts. It often happens, however, that the throughput is slightly reduced by this change; but in considering wages only, the reduced number of charges should result in a saving.

Another objection to the 4-hour break between shifts is the difficulty in regulating the quality and the additional work put on parts of the plant during the concentrated period of rapid gas production. With regard to all the overhead charges such as salaries, collection, and management and administration, the costs under these headings would not be affected by the grade of gas. The number of therms sold is for all practical purposes independent of the grade; and no change can affect the costs per therm, unless the calorific value were put so high or so low as to cause numerous complaints, which would result in additional clerical work and greatly increased inspection charges. There is as much danger in going too high as too low; but the responsible official is not likely, except in emergencies, to go to such extremes as would bring trouble of this nature.

Repairs.—In considering repairs, the term must be used in the widest sense—*i.e.*, the estimate must be based on the total provision which is to be allowed for maintenance, repair, and ultimate renewal of the plant in either its original form or replacement in a modern form.

Taking meters as a simple example, the maintenance pure and simple may be very small, and independent of the grade or quality; but the repair of leathers would certainly be more with a low-grade gas devoid of oily matter or with an excess of oxygen. The life would also be distinctly less, with the result that the effect on the costs would not be immediately apparent. In a very few years the repair and maintenance would mount up in the case of the lower grade, and in (say) 10 to 15 years the effect of the shortened life would result in an abnormal expenditure in replacements.

In making comparisons between different works and different systems we are again faced with the lack of a standard method of cost allocation. In works "A" certain men are allocated to wages; in works "B" the same class might be allocated to maintenance, making the wages for "A" appear high and the repairs for "B" correspondingly high. Further, one undertaking debits to residuals what another would debit to maintenance. This difference extends also to the materials and standing charges such as inspection and supervision.

An examination of the repair and maintenance costs of many undertakings will show that approximately one-half of the total is expenditure on wages paid to the employees of the undertaking in question; and there are certain items which would be independent of the quality of the gas manufactured, so that the cost per therm would simply be a fixed annual charge divided by the number of therms sold.

With regard to the maintenance, repairs, and renewals of the exhausters, washing plant, purifiers, and gasholders, it is clear that a low grade of gas would necessitate a larger piece of plant in each case; and consequently the fuel, oil, paint, and general attention would be more than in the case of a higher grade, and the cost of repairs and renewals would be higher. Consequently the higher the quality the lower the repairs and maintenance costs would be.

The estimates for the corresponding expenses for the carbonizing plant and coal and coke handling machinery are not such simple matters, however, though considerable assistance is given by the experience of the past, and certain basic considerations. For instance, for coal handling, the cheapest plant per therm would be that handling the least coal, and therefore the system producing the lowest cost in respect of this item would be that producing the maximum number of therms per ton. The same would apply to the coke plant. In both, however, certain fixed charges must be met, and the time element must be a factor, as a plant handling no coal or coke would require a certain amount of maintenance. Further, a large plant on a reduced tonnage would not show the same saving as a new plant of smaller size.

In the case of charging machinery, there are certain maintenance charges which are fixed amounts, and other variable charges dependent on the type of machine, and speed and amount of coal dealt with; but probably the heaviest part is that caused by the wear of the chain and portions which are put into the retort. Consequently the lowest cost of upkeep is that which entails the minimum number of charges put in the retorts for each 100 therms manufactured.

With regard to the retorts proper, higher heats entail higher repair charges; but the additional therms obtained by increased throughput and higher thermal make per ton may well compensate for this. The throughput of coal is dependent substantially on combustion-chamber temperatures; and in conjunction with this one must consider whether the charge can be adequately burnt-off in less time than that actually employed. In other words, high thermal yield cannot always be maintained in addition to high throughput. A more important factor in retort repairs, however, is the variation in the heat of the retort caused by the introduction of cold coal, coupled with the damage due to the insertion of the chain and pusher head. Consequently the least expensive method for each retort is that which gives the greatest number of therms per charge

In comparing types of carbonizing plant, the repairs of the simpler types of plant will obviously be less than those more complicated. Therefore the repairs to a water-gas plant or a complete gasification plant should be lower per therm than other systems, for two reasons :

(1) Less costly on account of the actual material in them.
(2) More therms produced per ton of coal or coke.

The size of the unit is of importance, for it is costly to throw-out a unit forming a substantial proportion of the daily make for a repair in a limited part of the setting. This causes wear and tear on the spare plant put into operation, and the expenditure on the actual repair is higher than it need be per therm of gas made. For instance, supposing a defect in a bed of horizontals necessitated resetting from charging-floor level. If a bed of ten throughs were involved, this might cost £450, whereas if the economic unit of the works is more like six retorts, the corresponding repair would only be £275, or thereabouts.

Capital costs are dealt with later, but the first cost has a bearing on the charge necessary for complete reconstruction or replacement due to obsolescence.

The effect of the annual charge for sinking fund based on a useful life of (say) 35 years would not be important when divided over the gas made annually. The difference between the cheapest and the dearest plant would not be likely to exceed 0·05d. per therm manufactured.

In dealing with existing plants, the rival claims of thermal make per ton, per retort per day, and per charge have to be considered. The following table is based on a make of 10,000 therms per day, with 23 in. by 16 in. retorts 20 ft. long, or (say) 18 ft. run effectively charged. The tons of coal used may be said fairly to represent the "net coal factor," the retorts at work the "capital factor," and the retorts charged per day the "wages factor." The "repair factor" would be a combination of retorts charged per day and retorts at work.

With a fixed combustion-chamber temperature, the distillation temperature would be higher when less coal is being carbonized in the retort; and consequently it is more

—	6¼ Therms per Ton.			6⅔ Therms per Ton.			7½ Therms per Ton.		
	Hours.	10 Hours.	12 Hours.	8 Hours.	10 Hours.	12 Hours.	ours.	10 Hours.	12 Hours.
Tons of coal used (net coal factor) .	156	156	156	147	147	147	139	139	139
Thickness of charge (excluding scurf)	7·6 in.	9·1 in.	10·7 in.	7·6 in.	9·1 in.	10·7 in.	7·6 in.	3·1 in.	10·7 in.
Percentage of sectional area filled (excluding scurf)	56	67	77	56	67	77	56	67	77
Retorts at work (capital factor) . .	104	108	113	98	102	107	93	97	101
Retorts charged per day (wages factor)	312	259	226	294	245	214	279	233	202
Thermal make per retort	96	92 5	88·5	102	98	93	108	103	99
Thermal make per charge . . .	32	39 5	44·2	34	41	46·5	36	43	49·5

The table is based on 10 cwt. for 8-hour charges, 12 cwt. for 10-hour charges, and 13¾ cwt. for 12-hour charges.

difficult to get the increased yield per ton from heavy charges without extending the time of carbonization. The ideal is to strike the balance by arriving at the quantity best carbonized in a given period, without losing throughput and burning fuel in an endeavour to knock out a further therm or so per ton. There is a danger of therms per ton becoming a fetish, as in pre-war days "high makes" per ton were deemed a virtue without any other consideration. If the high yield per ton could be got in eight hours, the repair costs of operating 93 retorts with 279 charges per day must be balanced against 101 retorts (say one more bed) with only 202 openings per day. The total differences, however, would be small and less important than those due to differences in the design of plant or the quality of materials and workmanship in the setting.

It has been claimed that deliberately lowering the throughput enables emergencies to be met, but it is doubtful whether it would not be preferable to adhere to the most economical retort-house working, and take up emergencies with auxiliary plant. In verticals, of course, steaming is of emergency value; and it is possible to increase the percentage of steam, and compensate for the lower calorific value, by using more oil in the water-gas plant. If there is no water-gas plant, then extra steaming does not offer any substantial attraction in this respect.

With regard to mains and services, it has been shown earlier that either larger mains must be used with a lower calorific value, or, alternatively, increased initial pressures. The capital costs of mains or operating costs of boosting must be taken into account; but only the repairs are for the moment under consideration. There is little doubt that the low grade causes increased running costs for maintenance and renewal of services; and the chief expense would arise in relaying services in a larger diameter, and replacing all services on the district on a larger scale when the first replacement is complete. The same would apply to mains. Therefore, even if the distribution system is capable of dealing with the lower quality, the system loses a potential margin for increase which it would possess if the calorific value were kept at a higher figure. There is no doubt, therefore, that the district repairs, as well as the over-all distribution costs, would be higher with low-grade gas.

With regard to the repair of meters, it will be admitted that any given size of meter is capable of registration of more therms with a high-grade gas than with a low. Consequently, if a substantial drop in calorific value were to take place, it might be necessary to enlarge some meters on the district, with a consequent increase in maintenance per therm sold. Reference has already been made to the increased costs of maintenance due to low-grade gases produced by "stripping" and other methods of manufacture.

At the same time, in many houses the meter maintenance is probably a fixed item, in which the time element is the principal factor; and, therefore, the cost of repair as a total would be independent of the calorific value, if kept within reasonable limits.

The best way to reduce meter repairs is to increase the annual consumption.

It is of interest to examine the probable maximum hourly consumption per consumer during the year; and the following table is compiled from information furnished by the engineers of the various undertakings concerned.

The figures of consumption per hour appear very low, and the table shows the further scope for increase in gas consumption in any type of town; and it seems to prove that a very large proportion of the meters on a district are of ample size. The great difference between the figures for similar industrial towns like Birmingham and Leeds is worthy of note.

Table of Maximum Day and Maximum Hour.

—	Max. Day. Thousands C.Ft.	Proportion of Yearly Send-out.	Maximum Hour. Thousands C.Ft.	Factor Day. / Max. Hr.	C.Ft. per Consumer per Max Hr.	Therms per Consumer per Max. Hr.
Birmingham . . .	50,610	1/141	3,750 (48,007)	12·8	18·7	·088
Cardiff	7,507	1/136	897 (4,585)	5·1	18·3	·086
Commercial . . .	18,083	1/146	1,338	13·5	11 1	·053
Derby	6,271	1/136	480 (3,029)	6·3	12·2	·061
Gas Light and Coke Company . . .	166,000	1/145	12,300	13·5	12·9	·065
Harrogate . . .	1,824	1/155	127	14·4	10·8	·050
Leeds	13,861	1/115	925	15·0	7·6	·036
Pinner.	631	1/125	60	10·5	13 6	·068
Sheffield	20,179	1/160	1,500	13·5	13 3	·066
South Metropolitan Company . . .	67,291	1/134	6,029 (42,117)	7·0	14·9	·083
Stretford	2,652	1/180	188 (2,590)	13·8	12·6	·060
Tottenham . . .	12,595	1/141	1,275 (8,738)	6·9	14·1	·070
Widnes	1,822	1/125	125	14·4	14·5	·072

Note.—The factor $\frac{\text{Day}}{\text{Max. Hr.}}$ relates to the day's send-out in which the maximum hour occurs.

In cases where the maximum hour does not occur on the maximum day, the send-out in the day comprising the maximum hour is shown in brackets.

An interesting note on the subject of maximum hourly consumption is given in the case of two undertakings of residential character. The maximum hour is no longer the Sunday cooking load, but (in the first case) the breakfast hours of a winter morning, caused by the combination of lighting, gas-fires, and cooker hotplates. In the second case it is on Monday morning, when the weekly wash is in progress.

To return to the subject of repairs, the repairs to cookers and fires would appear to be independent of the calorific value. The burning of gas involves the use of the cooker; and the cost of maintenance is dependent more on the type of appliance chosen and the treatment given it by the individual consumer. Inspection charges represent a proportion of the cost; and the care given to the original adjustment, coupled with the consistency of pressure and composition, is of more importance than the choice of the calorific value. Other things being equal, the repair cost is a function of time and gas consumed.

Therefore, the position under the thermal (as compared with the volume) basis is unchanged; and, as a rough rule, the more the appliance is used, the less is the upkeep per therm.

(9).—CAPITAL COSTS AND RATE OF INTEREST ON MONEY.

This factor is of great importance when new plant is under consideration, as money is usually dear at the time the required plant is most expensive. The thermal output must be considered in conjunction with the annual interest and sinking fund (or interest and depreciation) charges based on the estimated useful life of the plant; and in making the choice the necessary expenditure to other parts of the plant (if any) must be considered.

Simplicity of design is of importance; and the plant should be capable of renewal in comparatively small sections, avoiding the renewal of substantial parts of the work, as the wear may be confined to small portions. The

size of the unit must be considered, as a section used at a small proportion of its output is costly. The capital and sinking fund charges should therefore be assessed on the estimated requirements, and not on the maximum capacity.

The following table gives approximate costs of a plant making 10,000 therms per day, including coal stores, coke and coal handling plant, generating plant, and preliminary condensation. The useful life is taken at 33 years (1 p.ct. sinking fund on 6 p.ct. basis), and the interest at 6 p.ct. If the nature of the plant necessitates a shorter working life, then the sinking fund must be adjusted accordingly.

The annual make is taken at 240 maximum days = 2,400,000 therms.

Type of Plant.	Cost.	Interest and S.F. per Annum at 7 P.Ct.	Interest and S.F. per Therm Made
	£	£	d.
Horizontal retorts	40,000	2800	0·28
Vertical retorts	50,000	3500	0·35
Carburetted water-gas plant	26,000	1820	0·18
Tully plant	30,500	2135	0·21
Robinson plant	42,500	2977	0·30
Parker low temperature	112,000	7840	0·78
Maclaurin ,, ,,	60,000	4200	0·42
Nielsen ,, ,,	25,000	1750	0·175
Marshall-Easton ,,	33,000	2310	0·23

From the above figures it is clear that the lower-grade gas is considerably cheaper with respect to capital; and this is to be expected where the process consists in the more or less complete gasification of the fuel. In addition to occasions when new plant is required, a change of calorific value may involve capital expenditure, or alternatively result in postponing it. Owing to the trend of markets, a lower calorific value may result in a great saving in manufacturing costs, but entail heavy capital expenditure in mains, services, boosting plant, or even storage plant. Therefore, the economic effect of this expenditure must be balanced against the savings. If the relative values of coal and residuals appeared to be stabilized at such a ratio that low-grade gas would be cheaper over a long period, then it is probable that the savings would not be swallowed-up by distribution expenditure; and if in the future the balance should be affected, then the money so expended would probably be fruitful in taking up increased business. Each case must be considered on its merits.

Coal Conservation.

It has frequently been asserted that coal is conserved to a greater extent by carbonizing systems producing a large number of therms per ton of coal, but the figures and conclusions drawn therefrom usually ignore the utilization of the solid fuel distributed. Consider two processes:

(*a*) One ton of coal gasified by producing 70 therms of gas and 10½ cwt. of coke and breeze for sale.

(*b*) One ton of coal gasified completely by producing 175 therms of gas; this process requiring also 3¼ cwt. of coke.

In process (*a*) the gas undertaking must carbonize 2½ tons of coal to manufacture 175 therms; but this amount of coal releases 26¼ cwt. of coke, or 29½ cwt. of coke more than process (*b*). By withdrawing this quantity of coke, the market would need solid fuel (coal) to the extent of at least 25 cwt.; so that process (*b*) requires 20 cwt. *plus* 25 cwt. = 45 cwt. before satisfying equal requirements, against 50 cwt. for process (*a*). The difference is therefore very slight. In many industrial applications the amount of coal would be at least equal to coke, so that the above figures do not overstate the case. If the withdrawal of solid fuel under process (*a*) resulted in an increased sale of gas giving greater efficiency than solid fuel, then the figures would be more favourable to process (*b*); but this cannot be guaranteed.

Wastage.

Wastage is of two kinds:

(1) That caused by incorrect adjustment of the appliances.

(2) That caused by the householder.

With regard to (1), there is little doubt that a very high calorific value is liable to lead to more wastage than a very low grade; and, of course, the consumer has no control, or at best only a partial control, over this form of loss.

With regard to (2) this falls under three main headings:

(*a*) Burners lighted unnecessarily.

(*b*) Burners kept on after the work is done, such as a boiling ring left on after the kettle has boiled.

(*c*) Taps turned on too full, causing the flame to reach round the sides of the vessel, or resulting in inefficient lighting of a mantle.

Wastage under (*a*) is merely a function of time, and is independent of the calorific value, as the thermal units per minute reaching the burner should vary only within narrow limits. The same applies to (*b*), for it cannot be conceived that the wasteful user will leave the burners on longer than is necessary with a high grade any more than with a low grade. With regard to (*c*), it is probable that more wastage will occur with a high grade, particularly in lighting; and this can only be cured by repeated advice and education.

With reference to leakage, it is probably unaffected by the grade. Low grade requires higher pressures; but a certain sized orifice would deliver no more thermal units in a certain time, as the increased volume lost due to higher pressures would contain less heat units per cubic foot. The unaccounted-for gas due to difference of temperature between the station meter and the consumer's meters is unaffected by the grade. The unaccounted-for gas due to loss in registration by defective leathers and mechanism is likely to be increased by low-grade gases, though it is difficult to estimate the effect in figures.

On the balance, therefore, keeping to a high grade will not increase the leakage and unaccounted-for, but a lowering of the value might have that effect.

Discussion.

The President: You will agree with me when I say that Mr. Evetts has given us a most able paper and a most comprehensive one, on which he must have spent an enormous amount of time gathering together the information he has presented to us in tabulated form, which will be of the greatest value to the Institution. I am glad to find so many here to listen to this paper; and though we have not much time to discuss it, I know there are several gentlemen here who would like to take part in the discussion. Mr. Marshall's name has been mentioned in connection with one or two processes, and I will ask him to open the discussion.

Mr. Marshall: We have had the privilege of listening to a most interesting paper, and I personally wish to tender my thanks to the author. As my process has been mentioned, and as the whole subject of carbonization, whether at high or low temperatures, is connected with the thermal basis, perhaps I may be permitted to criticize or traverse some of the statements made—not because there is any disagreement between us, but for the reason that the paper was in print before I had the pleasure of meeting Mr. Evetts and having a talk with him over the matter. This question of low-temperature carbonization has been exercising our minds for a great many years. I personally have been nine years at the work. I have put down a works at Battersea, and through this plant I have put 2000 tons of coal, representing samples from every quarter of the globe, and I suppose I have been able to tabulate, with Mr. Tozer, results which have never been tabulated before, as far as the yields of gas and oil are concerned. What we have been striving for is not alone to get a smokeless fuel, but to get an oil which would render us quite independent of the American imported oil or oil from any other part of the world. We have been successful in obtaining oils which are equivalent to the best American oil imported into this country, and from our oils we have been able to extract a petrol with which we have driven a motor-car 300 to 400 miles with results equal to the best petrol in the world. All this can be got easily from some of our best gas coals. The question is whether low-temperature carbonization can pay. My view is that it cannot as an entity. If it is to stand alone outside the gas-works, there is no commercial prospect for it at all; but if you can use the low-temperature process in combination with a gas-works, then there is a very great future, in my humble opinion, for low-temperature carbonization. First of all I might say that I have had charge of many high-temperature works, but honestly I have always felt that we were wrong. I have not, however, been in a position to prove it, or say very much about it hitherto, or do much to mend matters. As an individual, I felt that we were going beyond the limits of economy in pressing our retorts to 2200° Fahr., and I do not think any of us know what the last 3000 c.ft. of gas per ton costs in reality. I have often discussed the matter with my brother-in-law, Mr. Goulden, of the Gas Light and Coke Company, and he has sometimes agreed with me that we have got to the limit of

economy in high-temperature carbonization. But coming back to low-temperature carbonization, what I am proposing to do, and have done, is this. The retorts I have put up hitherto have been static retorts—*i.e.*, to charge at the top and discharge at the bottom, at intervals of four hours. Each retort contains 5 tons. There are three rings of holes one above the other, and the heat is taken from the periphery to the inner rings. I have a working plant at the present time in operation in Natal, and there is another one being erected in Japan; but I feel that this is not finality. We can work it very well with Natal labour and with Japanese labour, but such a plant would be absolutely impossible if we tried to work it with British labour. Therefore I had to start all over again. Some years ago I lectured at Manchester before the Manchester Association of Engineers, and I told them plainly that I saw through a glass darkly as to how far low-temperature carbonization would help the gas industry; and for some years after that the glass was always obscured. It was only through working the Tully plant that I arrived at some definite means which cleared my thoughts. Whatever we think of the merits and demerits, we must agree that we owe Mr. C. B. Tully an immense debt of gratitude for what he did; and though I have had disputes with Mr. Tully, I look upon him as one of the pioneers in a line of thought which, if followed up, will help us very much in the future. What I wanted to get at was to make the retort continuous. I did not care what type of coal was used, whether it was the stickiest coal in the world. If I could induce that coal to travel, I knew it would be all right. Therefore, I set to work to design a plant, and I have erected it in my own garden. I have got coal from the Walton and Weybridge Gas Company, which is the stickiest stuff I have ever handled, and a piece the size of an egg will swell to the size of a coconut. I have been able to compress that into a solid coke containing from 10 to 15 p.ct. of volatile matter, and I have been able to get that coal absolutely down the retort without the slightest trouble. Moreover, I have been able to get 24 gallons of oil, which is some of the most remarkable oil I have ever seen. I have brought a small bottle of it with me. It is so volatile and so inflammable that, if you put a knife into it and strike a match, it will flame up like petrol. I have 24 gallons of that from this little retort. The great thing is what we can do with low-temperature retorts. If we have to heat them with the coke we produce, it cannot possibly pay, because we must take account of the cost of that coke. Following Mr. Tully's idea, which has been carried on by Prof. Stauffe, of Vienna, if we can get heat from an extraneous source without paying for it, then we will possibly be able to carbonize cheaply. If we have a water gas plant, we shall have more heat than we require to carry out low-temperature carbonization. It means that the low-temperature retort will give the fuel for the water gas plant, which in turn will give waste heat back to the low-temperature plant. Mr. Evetts has raised the question of what proportion of coke we must take to carry out low-temperature carbonization. In high-temperature work we used 26 therms of heat to carbonize one ton of coal—*i.e.*, we use about 2,600,000 B.Th.U., representing 10 p.ct. of coke, to heat a high-temperature retort. If we take a low-temperature retort, we only want half that amount, or 1,300,000 B.Th.U., to heat the retort, if I use the whole of the coke, but I do not want to. I can use a quarter of that coke, and still get sufficient heat to do what I want. If I use a quarter of the coke, which is equal to 46 therms, and deduct from this the heat required for steam raising and running the turbine, and the coke used in the process of water gas making, I get supplied to the generator 11 therms; and 11 therms is almost half of 26 therms which I should want if I were operating a high-temperature plant. If I take all the coke, I get 15 cwt. from the low-temperature carbonization process, and this coke contains 10 p.ct. of volatile matter. I then deduct 18 p.ct. for steam-raising purposes, which leaves me a net amount of coke of 12·3 cwt. If I use all this coke, which is 1377·6 lbs., and take 30 c.ft. of water gas per lb., I get 41,310 c.ft. of water gas of 306 B.Th.U. value. Then from the low-temperature retort I get a fixed quantity of 5000 c.ft. per ton, of rich coal gas of 800 B.Th.U.—that is, 4,000,000 B.Th.U., or 40 therms. If you can do this—as I say you can—and you add those 40 therms to the other therms, then you are doing very well indeed. The result therefore is 41,310 c.ft. of water gas, which gives me 126 therms, and 5000 c.ft. of rich coal gas, which gives 40 therms, or a total of 166 therms per ton of coal, but I have no coke to sell. In addition, however, I have 24 to 30 gallons of oil per ton. The question of the value of this oil depends upon the volatile matter in it. In my experience of thousands of gallons I have found that for every 1 p.ct. of volatile in the coal, you obtain from ½ to ¾ gallon of crude oil which will fractionate into petrol, light oil, heavy oil, lubricating oil, paraffin wax, and pitch; and the pitch is the most remarkable thing. It contains only 3½ p.ct. of carbon. If I use half the coke, I get 20,640 c.ft. of water gas, to which has to be added 5000 c.ft. of rich coal gas, this quantity being fixed, whatever proportion of coke I use. Thus I get 25,000 c.ft. of gas in all, or 103 therms per ton of coal. If I take a quarter of the coke, I get 15,000 c.ft. of mixed gas, or a total of 71 therms per ton, and I get 9 cwt. of coke for sale in the latter case, or 6 cwt. if I use half the coke. The process is so elastic that you can get gas of from 306 to 500 B.Th.U. by regulating the supply of coke put into the generator.

Dr. E. W. SMITH: One feels very tempted to follow up Mr. Marshall on this question of low-temperature carbonization; but as it is not to the point, I do not think I will say more than that the scheme which Mr. Marshall propounds—one in which the low-temperature carbonization process is to be wedded to a gas-works, and one in which the waste heat normally used for raising steam is to be used for heating the retorts—is not one which is attractive to the gas industry. Then there is another point. If such a process has no attraction to anybody outside the gas industry, we shall want a lot of convincing as to why the gas industry should carry the baby. If it is really of value as a low-temperature process—and Mr. Marshall is satisfied that low temperature is now an assured success—the gas industry will also want to be assured of success if it takes it up. There are one or two points in connection with the paper to which I should like to refer; and I think this is the type of paper that should be more general. I think Mr. Evetts would like to have accentuated that he does not desire to indicate more than tendencies in methods of looking at things. I think he makes that point time after time in a guarded way. These tables in the paper must not be taken as standard tables for comparison; they must be taken as being indicative of how to work out your own results for your own comparisons. I should like to ask Mr. Evetts whether there is a misprint where he gives verticals, light steaming, as 57 therms per ton. I think it would be very bad coal and very bad verticals if anything less than 70 therms per ton were obtained under these conditions. I think it is probably a misprint, but it just shows you how important it is when engineers and first-class accountants get together, to get down to relative values of different systems, that the primary thing is for the facts to be right, because a small discrepancy like that may vitiate the whole of the results. I do not say it is so in this case; but it is a point to be met. There is another point I should like to ask the author, though perhaps he has not gone into the matter in sufficient detail to be able to answer at once; and that is to have an evaluation in greater detail of the relative advantages of the two recommendations he makes. He advocates high-grade gas because of distribution, but he does not give us enough leading as to the comparison between the cost of distribution generally and in detail, and the cost of production and management. Then, later on, he strongly advocates, for other reasons, 360 B.Th.U. gas. He does not give this figure, but he supports complete gasification. Now, can he put these two things together, and say, from the point of view of the distribution of 500 B.Th.U. gas, that it will pay handsomely, and from the point of view of the production of 360 B.Th.U. gas, that pays handsomely.

Mr. F. H. ROBINSON (Harrogate): Mr. Evetts states that as a general rule water gas does not pay if 55 p.ct. or more of the cost of the coal is obtained from residuals. At Harrogate last year, with a complete gasification plant, with the price of coal at 27s. per ton, I estimated that the cost of complete gasification would equal the cost of straight coal gas making when the price of coke was 10s. or 11s. per ton higher, and that means that, with coal at 27s. per ton, coke would be from 37s. to 38s. per ton for the cost to be equal on the two systems. When I state this, I am basing it on a complete balance-sheet, and not upon thermal efficiencies or anything of that kind—*i.e.*, to take so much plant of the one type and so much plant of the other kind, and bring the figures together, and see what labour would be required to work the two plants in conjunction, and add for repairs, and strike a complete balance to produce a certain cost. If you do not take a complete balance-sheet, I say that the figures are misleading in every case. If we take materials alone, ignoring other factors, we should have required a difference in the coke price of 15s. or 16s. a ton to bring the two costs the same. While on the question of cost, and the cost per therm, I feel it is too often the case that cost is the only thing considered, and that the poor consumer is left out of account, for the reason that, when coke is cheap and coal is relatively dear, the policy seems to be water gas, and you reverse the policy when the conditions are the opposite. But what is the consumer to do in the meantime? On the one hand, you are going to give him a gas of a certain composition, perhaps with 10 or 15 p.ct. of CO, while with straight coal gas you have about 7 p.ct. of CO, and the quality, composition, and specific gravity are completely altered, and all the apparatus of the consumer is thrown out of order. I think the policy should be to reduce the amount of coal you carbonize, and reduce the amount of coke you produce, and make yourselves more independent of the fluctuations in these markets; and by that means you will attain greater stability. That has been seen recently, particularly on the north-east coast. I have in mind a certain works where they have several thousand tons of coke on the works, which are the same size as my own, and where the policy in the past has been to make straight coal gas with large quantities of coke for export. But they are in a pickle

at the present time, owing to the state of the coke market; and if there had been some policy followed of the kind I have indicated, they would have been in a different position to-day. Mr. Evetts makes a statement with regard to the repair and wages costs on complete gasification plants; and after stating the figures for Harrogate, he adds "presumably on the same basis." That is so; the figures include everything from the time the coal leaves the coal seller to the time the final materials are put into the yard in the shape of coke and ashes. As to the value of two shifts per day *versus* three, we have worked in this way for the past nine years; and from our point of view there are several advantages. You have less repairs and maintenance; you have a reserve machine; you have a reserve for an unexpectedly heavy demand; and you have a reserve in plant capacity for future extensions. With regard to the table dealing with the consumption per consumer per maximum day and maximum hour, I rather join issue with the author, because I feel that this table may be misleading. The factor $\frac{\text{day}}{\text{max. hour}}$, to be ideal, would obviously have to be 24 hours; and taking Cardiff and Leeds, the former has a factor of 5·1 with a consumption per consumer of 18·3 c.ft. In the case of Leeds the figures are practically reversed, and it seems to me that Leeds is in the happier position, because their maximum consumption is spread over a greater number of hours. I should like to thank Mr. Evetts for a very thorough paper; and I feel that it should be read in conjunction with Mr. Carr's paper.

Mr. S. SHADBOLT (South Bank): I think we must bear in mind that this paper is largely a collation of facts and figures from other people's working, and a reasoned consideration and statement of the case as Mr. Evetts views it. I speak as one on the other side, who, barring the slight stagger inflicted upon us by the coal strike of 1921, has for three complete financial years supplied a 400 B.Th.U. (gross) gas in my district, with very little variation and with a constant effort to stabilize, as near as one can, an ideal composition, and also with a close guard against unduly increasing the specific gravity. I have therefore made a few notes from that point of view. The author expresses the opinion early in the paper that thermal consumption will probably remain unaltered by varying the calorific standard. I am able to assure him, from actual observation of my own consumers, that, in the case of power consumers, you can almost work it out mathematically. You can get the volume which a man will burn on a steady load, just by simple proportion; but it is not nearly so reliable when you come to domestic consumption. Further on in the paper the author voices the opinion that I have uttered myself on more than one occasion—that there is considerable risk of wastage with the higher qualities of gas which is not there with the lower qualities. The author states: "Reducing the value might cause difficulties, but increasing it should not." My experience is that there should be no "messing about" with the value at all, because there are bound to be some difficulties. Then the question of high-grade gas and pressure is mentioned; and the author states that less pressure is required to deliver thermal units in a highly condensed form, due to the less volume to be dealt with; but for bunsen burner work you require more pressure to aerate your flame on the jet, because you want a bigger proportion of air. We have come across this in actual use. Finally, the author refers to wastage. He states that a certain size orifice will deliver no more thermal units in a certain time, as the increased volume lost due to higher pressures would contain less heat units per cubic foot. I am afraid he takes for granted a very finely balanced adjustment of pressures, which will never materialize in actual fact, and ignores the experience which many of us have met with—that with increased pressures you run the risk of sudden fractures. Both factors make any leak more serious, though, of course, they lead to a more rapid diagnosis and elimination of leakages. I have found in practice in my own area that an increase in pressure has been of assistance in keeping down the unaccounted-for gas. This leads me to my last point, which deals with the unaccounted-for gas in my district. For the last fourteen years the average unaccounted-for gas has been 5·65 p.ct. At the beginning of that period we were supplying 550 B.Th.U. gas, and for the last three full years, barring the coal strike period, we have supplied 400 B.Th.U. gas. During the first year of the fourteen years the loss was 6¾ p.ct., while last year it was 6·05 p.ct., and the average is 5·65 p.ct. There is an absolute case from experience which shows that the volumetric unaccounted-for gas need not be increased by decreasing the calorific value from 550 to 400 B.Th.U.

Mr. WATSON (Doncaster): Is this with the same make of gas?

Mr. SHADBOLT: It is the percentage volumetric leakage from the whole of the output. The works, of course, has progressed in fourteen years, as, I hope, every works has, and the output now is about 150 millions as against 100 millions. Taking the actual calorific value now, and before the war, while the leakage remains volumetrically about the same, the thermal loss has been reduced exactly 27·27 p.ct., and I think it is time that this point was observed.

Mr. MORLAND (Sydney): It has given me very great pleasure to attend these meetings. Unfortunately I have not been able to be present as frequently as I should wish, but the papers to which we have listened this morning are undoubtedly excellent. In the Colonies, of course, we do what we can to keep our methods and practice up to date, and we follow, as far as we can, English practice, unless we are able to discover something better ourselves. However, judging from my experience during this trip home and also other trips, I think that we in the Colonies are up to date in our methods. We have not yet adopted the therm system, because Parliament, unfortunately, has not permitted us to do so; but I anticipate that some day we shall be able to adopt the therm system, and we shall benefit in doing so. We have all sorts of plant in use in the Australian States—horizontals, verticals, and complete gasification plants—and we are working out for ourselves, as far as we can, the relative advantages of the different systems. In my works we make our gas by inclines, verticals, and water gas plant.

The PRESIDENT: Mr. Evetts refers in several parts of the paper to high quality and low quality gas. Perhaps he will tell us what he means by high and low quality gas.

Mr. EVETTS, replying to the discussion, said: I daresay you have tumbled to it by this time that the use of these terms is empirical. Anything over 500 B.Th.U. I call high quality, and anything under 400 B.Th.U. I call low-grade gas. Between these figures I have not any opinion as to whether it is high or low. With regard to Mr. Marshall's remarks, he has given us a very interesting series of figures as to what his plant could do, and I beg to assure him and every other maker of gas plant in this country that the Institution of Gas Engineers and the individual members, if they see a guaranteed proposition for making a cheap therm, do not care what this is made from, or what the plant is made of. They will look at it, and consider it, no matter whether it is high temperature, low temperature, or complete gasification. The method is immaterial to us; we want to make a therm cheaply. My objection to Mr. Marshall's method of attack (if I may say so—I have told him this in correspondence) is that I do not agree with him in taking a piece of everything, and then combining it in his plant, and saying: "That is what I can do." For instance, he gives 30 c.ft. per lb. of coke as the production of water gas of 360 B.Th.U. It may have been done, but how many of you are doing it to-day in your works as a practical proposition? Mr. Marshall says, further, that the heat from a quarter of the resultant coke in the low-temperature plant is going to provide sufficient heat to carbonize the coal. I cannot accept this proposition. He then calculates on 15 cwt. of coke or low-temperature fuel. This, again, is a result second to none. In other words, where can you find your coal to give you 15 cwt. of coke, the 20 or 24 gallons of oil, the 30 c.ft. of water gas of 306 B.Th.U. per lb. of coke, and the resultant heat from a quarter of the coke to gasify the coal? Dr. Smith has pointed out one or two things. The figure he mentioned in the table of net coal costs is a figure from the Fuel Research Board, and it so struck me that I draw attention to it. This coal was Lancashire washed nuts, and produced only 9670 c.ft. of 600 B.Th.U. gas, or 58 therms per ton, with 8·1 cwt. of coke for sale, when carbonized in horizontal retorts. Obviously it is not a good coal, and I put it in to show you that, by steaming it down to below 400, even with that inferior coal, you produce an extra 38 therms of gas at ¾d. per therm for the additional manufacture. Dr. Smith's comments on what I intended this paper to be are perfectly true. I wish each case to be considered on its merits; and in this paper I wanted to indicate lines of investigation for you to follow up for yourselves. He also asked me whether I can say, on balance, what is the right thing to do, whether the advantages of high-grade gas more than correspond, in distribution, to the advantage in the works of the manufacture of low-grade gas, and he supplied the answer himself. Of course, I cannot tell you. Each case has to be considered on its merits; and I would warn anybody against taking any short cuts with these things. The only thing, as has been pointed out, is to get a parallel balance-sheet for system A and system B, and run it to the bitter end. Do not stop half way, and say that A is the better. There must be no short cuts. The financial result has to be followed to the end with the various methods. Mr. Robinson has questioned my statement that as a general rule water gas does not pay if 55 p.ct. or more of the cost of coal can be obtained from the residuals. That relates to net coal only. This paper is divided into paragraphs, and only considers the points strictly arising within those paragraphs, and the 55 p.ct. refers to the net cost of coal, and is calculated by the usually accepted means of ascertaining the cost of coal, and the usually accepted balance of prices between coal and coke. Mr. Robinson also raised the point about ringing the changes on the calorific value owing to the trend of markets, and the difficulties likely to be caused to the consumers by changing the composition and specific gravity. I point out in the paper that we must consider if any change in the calorific value is likely to affect the satisfaction of the consumers. If it is, then do not make it, no matter what it would have saved you. I do not think I have lost that point

altogether. I am much obliged to Mr. Robinson for giving us the advantages of the 12-hour shift, but he must have a plant capable of dealing with 24 hours' gas, as it were, in comparatively quick rushes. Mr. Shadbolt has been good enough to give us the result of his experiences just on the margin of what I call low-grade gas, the 400 B.Th.U. He also asked me what I meant by saying that reducing the value might cause difficulties, but that increasing it should not. I have in mind there that in the case of three particular companies we have eliminated trouble with the consumers by going up from 475 to 500 B.Th.U. It may have been that it was the pressure which was the trouble at 475 B.Th.U., but the difference in the number of complaints was remarkable when we started to work towards the 500 B.Th.U. We first went up to 485, then to 490, and then to 495, all the while with a declared value of 475, and then we went up with our declaration when we were over 500 B.Th.U. In two cases out of the three the number of complaints began automatically to drop as we raised the value; and this was the reason for making the statement to which Mr. Shadbolt has referred. In my humble opinion you could increase it to 550 in most cases without causing dissatisfaction. Above 550 I have my doubts, particularly in my own house. Mr. Shadbolt also gave some interesting figures as to the way in which the leakage has been reduced. I do not think I put forward the suggestion that leakage was going to be made worse by low-grade gas. I simply said I would show how it could be made better. Mr. Shadbolt's figures are on a make 50 p.ct. greater; and one would except the leakage to be less with 150 millions than with 100 millions, particularly as probably in the meantime you have stiffened up your distribution department, and paid much greater attention to the consumers generally than you did fourteen years ago. In my opinion this fact alone should tend to reduce the amount of unaccounted-for gas.

The PRESIDENT: I should like to express, on your behalf, our gratification to Mr. Evetts for presenting this paper, on which he must have spent an enormous amount of time. I am certain that the opinion of the members will be that the last paper maintains fully the high level of the communications that have been received at our annual conference this year. I am sorry it was not possible to let the members have advance copies of some of the papers, but the Whitsuntide holiday was a week previous to the meeting, and I can assure you that everything was done to get copies into your hands as quickly as possible. The only thing I am afraid of is that, if we had let the members have the papers a week before, we should have had to have another session to-morrow instead of going to Derby. [Laughter.] I should like you to express your hearty appreciation of the paper, and to thank Mr. Evetts for it.

THE GAS INDUSTRY AND THE GOVERNMENT.

From the Ministry of Transport we have received the following announcement, dated June 9:

The Minister of Transport, who was accompanied by Sir Burton Chadwick, M.P., and Colonel Moore-Brabazon, M.P., received a deputation to-day, introduced by Mr. Milne Watson, representative of practically the whole of the company and municipal gas undertakings.

Mr. Milne Watson and other speakers indicated the uncertainty which prevailed in the industry at the present time, owing to their ignorance of the Government's proposals with regard to electrical development. The views of the gas industry were stated at some length by various speakers; and the Minister was asked to be good enough to indicate as soon as possible any proposals which the Government would consider might affect in any way the gas and the electrical industries.

Colonel Ashley, in reply, stated that it was impossible for him at present to indicate what any Government proposals might be; but he undertook to bear in mind the representations which had been made to him, and to see that due consideration was given to them. He would be glad at any time to receive representations from those interested.

Gas and the Cinema Industry.—In the "Capitol" Cinema—perhaps the most beautiful and most perfectly-equipped cinema theatre in Europe—the air can be heated in the winter and cooled in the summer in order to make the temperature comfortable, and before it enters the theatre it is cleansed of all impurities. Fog cannot enter the building, owing to the air being under a pressure slightly higher than normal atmospheric pressure. The "Plenum" plant, which carries out the double operation of cleaning and heating the air, utilizes a large gas-fired boiler for providing the heat, and thus ensures that neither dirt nor smoke is created in the heating operation. Full particulars of this plant, the boilers of which are situated on the roof of the building, are contained in the current issue (No. 135) of "A Thousand-and-One Uses for Gas."

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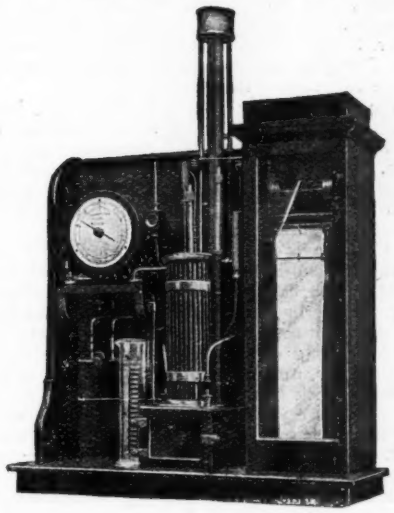

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DERBY GAS LIGHT AND COKE COMPANY.

Description of the Works.

The Derby Gas Light and Coke Company was incorporated by an Act of Parliament obtained in 1820 for lighting the town of Derby with carburetted hydrogen or coal gas. In 1841, a further Act was granted to the Company "for better lighting with gas the borough of Derby and several parishes and places adjacent thereto." By an Act in 1852, further powers were conferred, and by the Midland Railway (Derby Gas) Act, 1867, an exchange of lands between the Midland Railway Company and the Derby Gas Company was authorized, and provided for a site for new works at Litchurch.

In 1876 and 1890, and also in 1903 and 1906, Acts were obtained to enable the Company to raise additional capital and

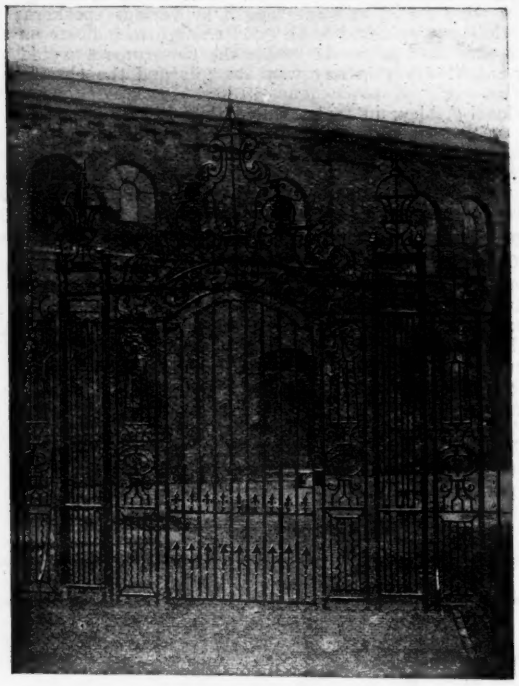


Fig. 1.—Eighteenth Century Hand-Beaten Wrought-Iron Gates—Cavendish Street Works.

extend further the limits of supply. The 1906 Act authorized the Company to acquire the two undertakings of the Spondon, Ockbrook, and Borrowash, and Mickleover and Etwall Gas Companies. In 1908, the purchase of the Belper Gas Company and Mr. Strutt's Milford Gas-Works was authorized, and the limits of supply were extended to include the districts supplied by these two undertakings.

By the Derby Gas (Charges) Order, 1921, thermal value was substituted for illuminating power, the charge for gas thereby being based on its potential thermal value, instead of its volume. In 1923, a Special Order was made by the Board of Trade under the Gas Regulation Act, 1920, to enable the Company to acquire additional lands at Litchurch and Belper for gas-works purposes.

The Company's area of supply includes the County Borough of Derby (extended from time to time), and also the districts supplied by the five amalgamated neighbouring undertakings. To-day the Derby Gas Light and Coke Company's limits of supply cover an area of some 85 square miles.

The authorized capital is £589,270, with borrowing powers up to £106,017, making a total of £695,287, of which £492,270 of ordinary stock has been issued, and £55,000 of 4 p.ct. perpetual debenture stock. There are in addition £69,635 premiums on stock sold by public auction, upon which no interest is paid. The total expended capital at Dec. 31, 1924, was £646,490.

The make of gas in 1900 was 595 million c.ft., and last year (1924) it was 1661 millions—being an increase of 1066 millions, or 180 p.ct. The mileage of gas mains in the last 24 years has been increased from 90 to 229, and the number of consumers from 18,234 to 38,851.

The Company do a large and increasing business in the sale of fittings, burners, globes, and shades for lighting purposes, and also by letting out, on simple and purchase hire, gas cooking stoves, fires, and all kinds of gas appliances for domestic and industrial purposes. The latest development is to let-out gas engines on simple hire. The price charged for gas used for lighting and domestic purposes compares favourably with that of most other towns, and special advantageous terms are given to industrial and motive power users.

The chief offices and showrooms are centrally situated in Friar Gate; the property on each side having been purchased to enable the Company to extend the main building when required. There is also a branch office and showroom at Belper.

The declared quality of gas supplied is 500 B.Th.U. per c.ft.

Litchurch Gas-Works.

The Litchurch Works are on the outskirts of Derby, on the east side, some two miles from the centre of the town. They adjoin the London Midland and Scottish Railway, and cover about 21 acres; there being a further 57 acres of land acquired by the Company for future developments. These works are divided by the Derby Canal; "A" works were inaugurated in 1867, and occupy about 10 acres; the new "B" works were begun in 1915, to enable the Company to meet the large increase in demand for gas required for war work. Access to "A" or "B" works is by means of a high-level road bridge, railway swing bridge, and two high-level foot bridges over the canal. From the main entrance of the works, a granite-paved roadway, 47 ft. wide, runs almost the whole length of the "A" section works.

At the right-hand side of entrance is an ambulance room. The Resident Manager's house and works offices are on the same side, a short distance inside the entrance gates.

The Works Laboratory is situated almost opposite to the offices, and comprises office and balance room, physical and chemical test rooms, distillation room, stores, and official gas-testing room.

The recording calorimeters and routine testing instruments are fixed in close proximity to the appropriate gas mains, in an annexe to the station meter house, about ten yards from the works laboratory.

The "A" works are divided into two, each section being a complete unit which can be operated separately or jointly by means of by-passes.

No. 1 Retort House is a cellar house 241 ft. long by 52 ft. wide, and contains 18 settings of 8 C-section retorts, 22 in. by 16 in. by 18 ft. long, or 144 through retorts. The settings are heated by 18 Klonnè regenerative furnaces, and the retorts charged and discharged by De Brouwer stoking machines. The charging machine is fed from continuous overhead coal hoppers of 24 hours' storage capacity. The seals on dip pipes are regulated by Dillamore tar columns, and the suction on each retort bench is controlled by retort house governor.

No. 2 Retort House is a stage-floor house, the same size as No. 1 house, and contains 22 settings—11 beds at the west end being 22 in. by 16 in. C-section retorts, and those at the east end 24 in. by 16 in.—all heated by Klönne regenerative fur-

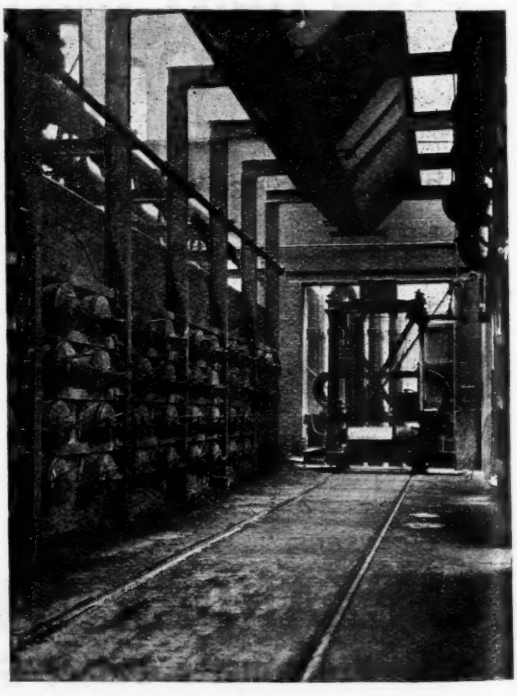


Fig. 3.—No. 2 Retort House, with D.B. Pusher—Litchurch Works.

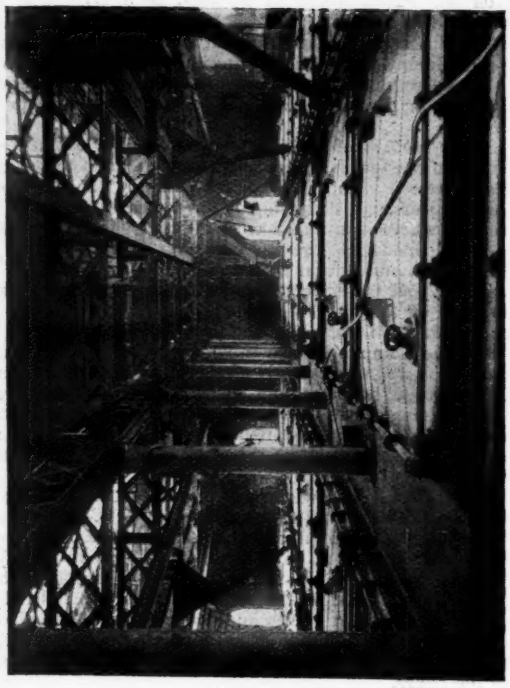


Fig. 4.—No. 1 Purifier ouse—Litchurch Works.

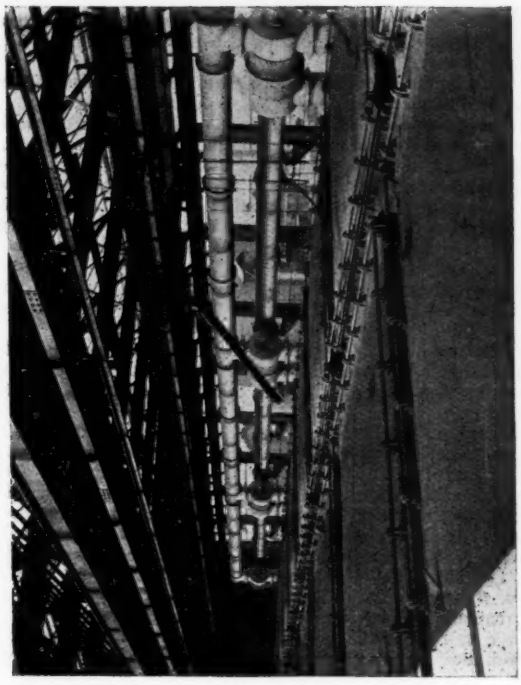


Fig. 57.—Purifier House for Coal Gas—Litchurch Works.

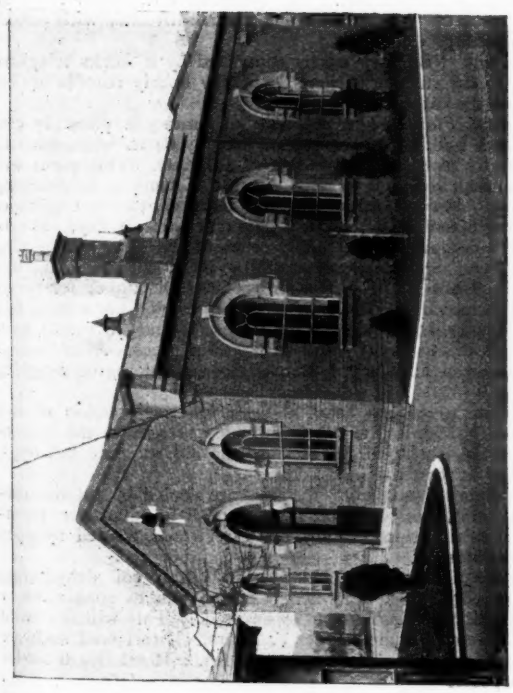


Fig. 2.—Laboratory—Litchurch Works.

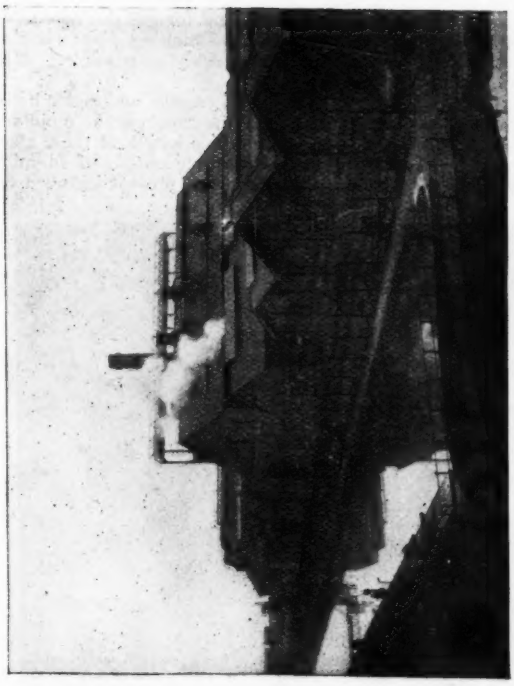


Fig. 5.—"B" Section—Litchurch Works.

naces. The stoking machines are De Brouwer, similar to those in the other house; the coal being fed into the charging machine from overhead continuous coal hoppers.

Each house has a separate wagon tipper, coal breaker, and elevator, constructed to deal with from 40 to 60 tons of coal per hour; the overhead hoppers being fed by longitudinal scraper conveyors. On the opposite side of the houses the hot coke, on being discharged from the retorts, is taken away by De Brouwer longitudinal coke conveyors and cross-inclined elevators, which pass the coke over screens into overhead storage hoppers for loading into railway wagons or carts.

The power for driving the coal and coke handling plants is obtained from gas engines fixed in convenient buildings adjoining the coal breakers, elevators, and conveyors, and varying in size from 25 to 70 H.P. The latter type of engine is in duplicate, and in addition to driving the coal and coke plants for No. 1 house, is belt-coupled to a 45-KW. electric generator, which supplies all the electrical power required for both "A" and "B" works.

Scrubbing and Washing Plant.—No. 1 Section consists of a 2-million c.ft. Livesey tar extractor, a tower scrubber, 12 ft. diameter by 60 ft. high, and a Kirkham rotary washer. No. 2 Section, when completed, will be similar.

Boiler House.—Five Lancashire boilers, each 28 ft. long, three of which are 7 ft. 6 in. in diameter, and two 9 ft. diameter, are fitted with steam superheaters. There are two batteries of economizers for heating the feed water by waste heat. Each boiler is constructed for 160 lbs. w.s.p., and is fitted with a turbine breeze furnace—coke dust or other refuse being used for steam raising.

Pump House.—This adjoins the boiler house and contains, in duplicate, Weir boiler feed pumps, Pearns treble-ram pumps for supplying water from the canal for works purposes, and Lee Howl liquor pumps for supplying ammoniacal liquor to the sulphate of ammonia plant.

Exhauster House.—This contains four sets of gas exhausters (driven by horizontal direct-coupled steam engines) each having a capacity of 120,000 c.ft. per hour. Each set can be coupled to either No. 1 or No. 2 Section.

Purifying House.—No. 1 consists of eight overhead purifiers. Each box is 30 ft. by 25 ft. by 6 ft., and each purifier is fitted with four luteless covers, and Milbourne fasteners and valves. There are four discharging shoots on the bottom of each purifier, the latter being filled by means of an oxide elevator and overhead band conveyor with suitable charging shoots. No. 2 house contains four purifiers, each 30 ft. by 15 ft.

by 4 ft. deep, with water lutes, on ground-floor level, operated by a centre valve. It is intended at some future time to replace these by eight larger purifiers fixed overhead, similar to those in No. 1 house.

Tar and liquor storage is provided under what was formerly a lime shed between No. 1 and No. 2 purifier houses.

Station Meter and Governor House.—This adjoins the purifying houses, and contains two station meters, each of 100,000 c.ft. per hour, with 18-in. to 24-in. connections and by-passes. There are three double-cone water-loaded station governors which control the gas supply on one 30-in. and two 24-in. trunk mains, and there is a smaller station governor for the outlying districts, to which gas is supplied by two high-pressure mains, one 18 in. and one 10 in.

A safety governor is fixed between the inlet and the outlet of the gasholders, so that, if the outlet valves are improperly operated, the gas supply is not entirely shut off.

Naphthalene Washer.—Fixed on inlet main to the gasholders is a 5-million c.ft. per diem rotary washer for extracting the naphthalene from the purified gas prior to its entering the storage holders.

The three gasholders are severally 125 ft. in diameter, 4 lifts; 90 ft. in diameter, 2 lifts; and 140 ft. in diameter, 4 lifts—all in brick tanks. The 125-ft. diameter holder top lift rises above the outside column framing, and is guided by wire ropes. The 140-ft. diameter holder has a flying top lift. These two were formerly two-lift holders, and were converted into four-lift holders to provide additional storage, which now totals 2¾ million c.ft. Including the Railway Company's and two C.W.G. holders, the total storage is 3,900,000 c.ft., which is small for works capable of making 4¼ million c.ft. of coal gas and 3½ million c.ft. of C.W.G. per diem. The maximum output of gas from the Litchurch Works is about 5⅓ million c.ft. per diem.

"B" Works.

These works were begun in 1915, to enable the Company to meet the large increase in the demand for gas during the war. It was imperative that additional gas-making plant should be erected and put into operation as quickly as possible. Hence C.W.G. plant was decided upon.

The Generator House, with boiler, engine, and meter houses, form one block of buildings facing the canal on the main roadway, 43 ft. wide, which runs the whole length of these works. This section is designed for an ultimate output of 10 million c.ft. of C.W.G. per diem. The plant at present installed comprises one 2-million c.ft. and one 1½ million c.ft. Humphreys and Glasgow C.W.G. sets. Attached, and serving either plant, is a vertical tubular waste-heat boiler, capable of producing all the steam required by one set. There is sufficient room in the generator house to erect three more C.W.G. sets. In the same building are two Lancashire boilers, each 30 ft. long by 9 ft. in diameter, fitted with superheaters and turbine breeze furnaces, and with a Green economizer at the back, for heating the feed water. There is sufficient room for three more boilers.

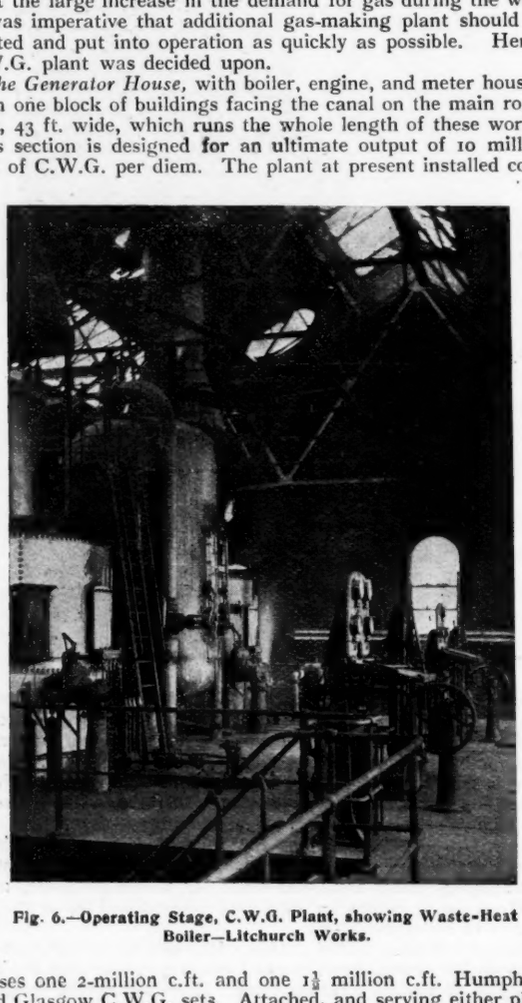


Fig. 6.—Operating Stage, C.W.G. Plant, showing Waste-Heat Boiler—Litchurch Works.

The water for steam-raising is softened by a Lassen Hjort plant.

The Blower House contains two Sturtevant fans, each driven by a 55-H.P. Greenwood & Batley turbine; and there is also a 120-H.P. Hodges steam turbo-blower capable of delivering 15,000 c.ft. of air per minute against 30-in. water-gauge pressure.

The Engine House contains two Bryan Donkin exhausters, each of 150,000 c.ft. per hour capacity, coupled direct to vertical high-speed enclosed steam engines, for pumping the gas from the storage holders and delivering it through a 24-in. main to "A" works, where it is mixed with the coal gas on the inlet main to the gasholders. The gas sent over is measured by a 150,000 c.ft. per hour station meter.

Weir service and boiler feed pumps in duplicate supply all water required on the "B" section.

The coke required for the production of C.W.G. or blue gas is carried by the Company's own railway wagons and shunting locomotives to a wagon tipper, is elevated, and stored in overhead coke storage hoppers, and discharged by shoots over screens into the generator by the hydraulic charging ram, thereby maintaining a constant depth of fuel in the generator. A hydraulic lift and bogies are provided as a duplicate coke-handling plant.

C.W.G. Purifiers.—The water gas is purified in four boxes on ground-floor level, each 40 ft. by 30 ft. by 6 ft. deep, with four luteless covers for emptying and filling. These purifiers are in a covered shed 141 ft. long by 49 ft. wide, with revivifying sheds on each side, 37 ft. wide, for the full length of the building. The gas through the four boxes is controlled by Milbourne inlet and outlet valves and connections, all of which are readily accessible. For filling and emptying, small electric travelling cranes, with tip buckets, run the length of the house alongside the boxes.

C.W.G. Holders.—Storage accommodation is provided by two gasholders in steel tanks. The ¼-million c.ft. holder is spiral-guided, and the ½-million c.ft. is a three-lift one, with outside guide framing.

"A" and "B" are works connected by a works telephone system to the various sections, whereby hourly records are obtained of the different operations.

Chemical Plant.—The sulphate of ammonia plant is contained in a building about 120 ft. long by 62 ft. wide, one-half of which is reserved for storage of sulphate. This plant was recently supplied and erected by the Chemical Engineering Company. It contains several new features, and is capable of producing 6 tons of dry neutral granular salt per day. It consists of a combined fixed and free ammonia still, with liming chamber and closed type of saturator fitted with a Wilton discharger. A small coil condenser provides the liquor for spraying and neutralizing the salt, which is carried on a steel belt conveyor over vacuum pipes, and then discharged into a horizontal belt-driven dryer fitted with steam pipes. After drying, it is delivered into bags attached to an automatic weighing machine.

Sufficient room has been allowed for the erection of two additional similar units. It is intended to remove the concentrating ammonia liquor plant from the old sulphate buildings, and to re-fix it in the new house.

The effluent gases from the still are cooled by tubular condensers, and finally by 800 ft. run of 8 in. diameter water-cooled cast-iron pipes. They are afterwards treated by open oxide purifiers.

The Tar Dehydrating Plant is a Wilton coil dehydrating plant, to which has been added extra coils to enable No. 1 Road Board Specification tar to be made. This will deal with about 20 tons of crude tar per 24 hours. Direct-fired stills are now in course of erection to produce No. 2 Road Board tar for road purposes.

Cyanide Plant.—The whole or any portion of the coal gas made may be freed from hydrocyanic acid content by being passed through a Pelouze tar extractor and a Holmes cyanide washer. The washing medium is prepared by precipitation of iron from copperas by means of a light alkali. From the circulating liquor, prussiate of soda is recovered in the form of yellow crystals by the Davies-Neil process.

"B" Works New Coal Gas Plant.

A start has been made by the erection of a large steel-framed building, containing four overhead purifiers, each 45 ft. by 40 ft. by 6 ft. deep; each box being fitted with four luteless lids secured by Milbourne's fastenings and with discharge shoots on the bottom. A new feature is that the inlet and outlet pipes for controlling the gas are overhead, and thus readily accessible. The oxide is elevated by a bucket elevator, which feeds on to a rubber band conveyor running the whole length in the centre of the house; and a travelling discharger with shoots enables the oxide to be filled into the purifiers with a minimum of labour. The oxide handling plant was recently supplied and erected by the Ewart Chain Belt Co., Ltd., of Derby. The ground floor under the purifiers and adjoining the revivifying shed is used for the preparation and storage of oxide.

Fig. 8.—Entrance—Cavendish Street Works.

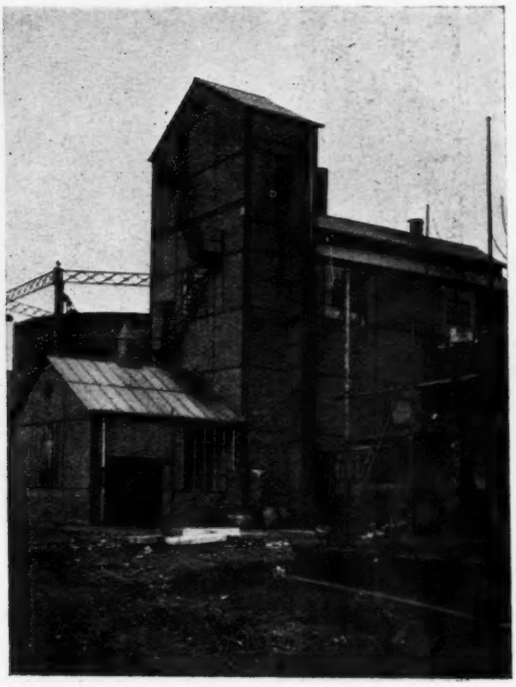


Fig. 9.—Tully Plant—Belper Works.

Station Meter House.—The meter house adjoins the purifier house and contains a 200,000 c.ft. per hour Parkinson station meter with the necessary 24 in. diameter valves and connections. The purifying plant is so designed that it can easily be doubled at any future time.

It is intended that the new "B" section coal-gas plant will be in 5 million c.ft. per 24-hours units, each section to be worked separately, similar to the "A" section.

Ample space is allowed for railway sidings in all directions, for future extensions, and especially for storage of coal, coke, and other residual products.

Cavendish Street Works.

This is the Company's original manufacturing station. It was erected in 1820, and has been entirely re-built and extended from time to time, and now covers an area of some four acres. These works are situated directly at the back of the chief offices in Friar Gate. It may be recalled that the first D.B. stoking machine was installed at the Cavendish Street Works and aroused much interest at the time. The carbonizing plant consists of both horizontal and vertical retort settings. There are six through horizontal beds of 8 Ω shape, 21 in. by 15 in. by 18 ft. retorts, operated by the D.B. latest type of combined machine. This is fitted with the latest pattern discharging ram; the old telescopic lengths, together with their catches and stops, being dispensed with. The Oxford safety device for holding-up the body of the machine in case of the hoisting chains failing is also fitted, together with electric cut-outs to prevent overwinding, &c. Extension of the power plant in connection with this machinery and the vertical installation is now under consideration.

The Vertical Retort House.—The bench, till it was recently demolished, comprised six beds of Wilson-Glasgow continuous intermittent vertical retorts—36 in all—having a nominal capacity of 1,000,000 c.ft. per diem. Coal is delivered through a single roll crusher, or direct to a gravity-bucket elevator conveyor which feeds overhead hoppers of 48 hours' capacity. The new bench is at present being erected by West's Gas Improvement Company, and will consist of five beds of their latest design. There will be eight 20-ft. retorts per bed, or 40 retorts, having a productive capacity of 1,400,000 c.ft. per diem. The existing steel stancheons, overhead bunkers, coal breaker, and G.B. elevator and conveyor, and the foul gas main, will all be incorporated in the new installation. A Kirke waste-heat boiler will be erected on the site of one of the old vertical retort beds, and it is expected that this boiler will give an evaporation of 3000 to 4000 lbs. of water per hour. The entire work will, it is anticipated, be completed in time for next winter's demand.

The exhauster engines at this station are of the vertical enclosed type, by Messrs. Robey & Co.; and the exhausters, by the Bryan Donkin Company, Ltd., have a capacity of 2 million c.ft. per diem.

The washing plant comprises a Livesey washer, a tower-scrubber, and a Holmes rotary washer. There are two sets of purifiers. No. 1 house contains four boxes, each 20 ft. by 14 ft. by 3 ft. 6 in., operated by double-faced Cockey centre valve, so that the boxes may be worked either three or four at a time. No. 2 house contains four boxes, 30 ft. by 15 ft. by 4 ft., operated by a Weck centre valve.

The gasholders, three in number, have a capacity of 500,000 c.ft. The governor house contains the station meter and station governor, a separate governor for the outlying districts, and a safety governor to correct improper gasholder valve operation. The exhauster house contains two sets of gas compressors, by the Bryan Donkin Company, Ltd., which may be used either for high-pressure distribution in the town or for pumping gas at 2 lbs. per sq in. pressure to Belper (8 miles), and feeding various villages through district governors *en route.*

The mechanics and blacksmiths shops have recently been enlarged; and at these works are garages for the steam wagons, lorries, motor vans, and cars required in connection with transport over the Company's extensive area of supply. The works office and chief stores, situated at the entrance to the Cavendish Street Works, have recently been extended, to allow more room for the numerous stores now required in connection with the distribution department.

An official testing station for these works and the works' laboratory have recently been erected, and are controlled from the Company's well-equipped main laboratory at Friar Gate.

The laboratory comprises the top floor of the general offices, and includes an office, photometer room, dark room, laboratory, balance and physical test room, store room, &c.

Belper Gas-Works.

The Belper Works of the Company, eight miles from Derby, are situated on the banks of the Derwent, and were purchased from the old Belper Gas Company about eighteen years ago. They are now connected by a high-pressure main to the Cavendish Street Works. A considerable part of the total area of 6¾ acres is available for extensions; the present output being just over 100 million c.ft. per annum.

A railway siding adjoins the retort house, thus facilitating handling of coal and dispatch of tar and liquor. The carbonizing unit consists of 6 beds of 8 stop-ended Ω-shaped retorts (operated by hand and heated by regenerative furnaces), and a Tully gas plant of 500,000 c.ft. capacity per diem, erected in a steel-framed building. This plant is utilized as far as possible to supplement the output from these works. It is fitted with a superheater, and by the addition of oil can produce high-quality gas, should this be required at rush periods. Temperatures are controlled by electrical pyrometers. This auxiliary plant has been very useful, and, considering its necessarily spasmodic operation, the results obtained are quite good.

Two additional Lancashire boilers, 28 ft. by 7 ft. 6 in., with superheaters in each case, have recently been installed. These boilers are suited for a w.s.p. of 200 lbs. per sq. in., and are fitted with turbine breeze furnaces.

Scrubbing and Washing Plant.—This comprises a P. & A. tar extractor, a Livesey washer, a Kirkham washer, and a Walker scrubber. The purifiers, 25 ft. by 20 ft. by 5 ft., are dry sealed, and are operated by Milbourne patent valves. The new section of the works is laid out for a daily output of 1,000,000 c.ft.

The gasholder, of 500,000 c.ft. capacity, is spirally guided; and there is a small relief holder (for Tully gas) connected to the hydraulic main in the retort house. The supply to the Belper district is governed by a 15-in. Parkinson double-coned station governor; and a second outlet from the holder feeds gas to the high-pressure main running back to Derby.

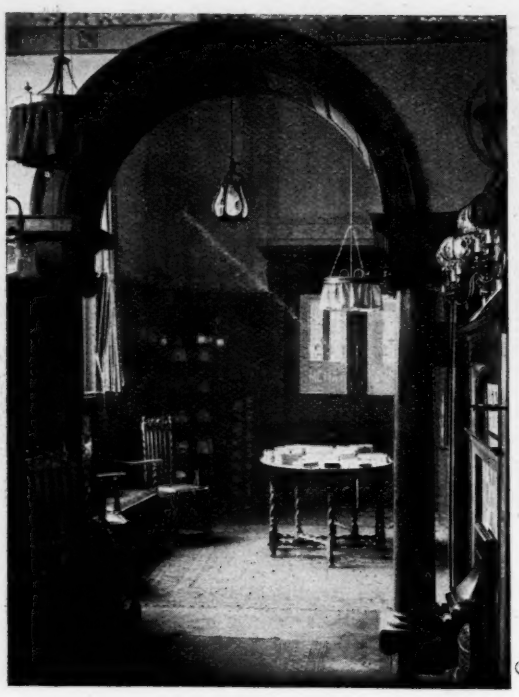


Fig. 10.—Entrance to Showroom, Friar Gate.

The works are equipped with mess room, office, and laboratory containing the official testing apparatus.

Distribution Department.

The showrooms are on the right-hand side of the main entrance to general offices, with a reception room (oak panelled), and a showroom divided into a number of recesses to exhibit various patterns of modern gas fires and fittings for lighting. The rear portion of the showroom is partitioned off by oak panelling, and contains a number of gas cooking stoves, and water-heating appliances. There are a porcelain bath, sink, &c., to enable various apparatus to be demonstrated in actual operation. An adjoining room is fitted with show-cases to display lighting fittings, burners, glassware, silk shades, &c.

The distribution office and shops comprise accommodation for the Superintendent, office staff, inspectors, and foremen; and there are also repair shops for dealing with meters, fittings, stoves, &c.

For many years the Company have supplied, and fixed complete, gas engines on hire-purchase; and recently it was decided to extend ordinary hire facilities to gas engines. The Company inspect, test, and maintain gas engines at a nominal charge; the result being that those who use gas for power purposes can rely upon a continuous power supply at the low figure of about ½d. per B.H.P. hour.

The Company employ a specially trained staff of fitters for piping houses, and fixing lighting installations, gas cooking stoves, fires, geysers, water-heaters, and all kinds of gas appliances for domestic and trade purposes.

Inspectors and canvassers keep the Company in close touch with consumers, and advise and estimate for their wants and requirements in all matters pertaining to the use of gas for lighting, heating, and power.

AT THE FULHAM GAS-WORKS.

The members who had elected to take part in the visit on Thursday afternoon to the Fulham Works of the Gas Light and Coke Company numbered 200 and more, and included the President (Mr. Ferguson Bell). They assembled at the Chief Offices of the Company in Horseferry Road, where Mr. Thomas Hardie (the Chief Engineer) awaited them, and punctually at the appointed time set out in motor coaches for the works. To the great disappointment of both the Governor (Mr. D. Milne Watson) and Mr. Hardie—and also, it need hardly be added, of the visitors—neither of them was able to accompany the party; it being explained that they had to remain in town to attend a meeting there in connection with the gas industry.

On arriving at the Imperial Wharfe entrance to the works, the members were received by Mr. A. H. Solomon, who offered them a cordial welcome, and in every way proved an admirable host. It was noted at once—from the very moment of forming the parties for inspection—that the most complete arrangements had been made by the Company for the comfort of their guests, whose path from start to finish proved a smooth—if somewhat hot—one. Many points about the Fulham Gas-Works struck the members of the Institution favourably, and not least among these must be placed the efficient organization which was revealed in the planning and carrying out of the programme. Mr. Solomon was everywhere, and all the officers detailed to assist were everywhere; no one had need to go without any information he might desire; and yet there was no crowding at all. Mr. Samuel Glover, with long and varied experience of visits to works, was warm in his praise of the excellence of the organization and of the services of the guides; and the reception which his remarks met with showed how thoroughly his hearers were in accord.

So much having been said, it would be unfair to leave the story incomplete; so we will add that the visitors were divided into six parties, all neatly badged, and were placed under the leadership of (1) Mr. Grogono, (2) Mr. Calvert, (3) Mr. Davies, (4) Mr. Tanner, (5) Mr. Parkinson, and (6) Messrs. Ball and Holdway. To these parties were attached the following members of the engineering staff: (1) Messrs. Hunter, Richmond, and Barclay, (2) Messrs. Mitchell, Anderson, and Royle, (3) Messrs. Wood, Wallington, and Tutton (Construction Department), (4) Messrs. Stewart, Culbertson, and Lacey, (5) Messrs. Hutchence and Cooper (Construction Department), (6) Messrs. Sheridan and Phillips (Construction Department). In their tour the visitors were further aided by an illustrated brochure, the description contained in which is given below.

From this description, some idea will be gathered of how much there was to be seen. It is always a treat to be privileged to inspect constructional operations on a gas-works; and the treat was offered here in no unstinted measure. First of all (taken in the order of inspection) there was the strengthening of over 290 ft. of river wall; and the crane track, upon which two electric cranes, of 125 tons per hour each, will operate. A reinforced concrete hopper to store 2000 tons of coal is being constructed; and under this has been completed the conveyor pit, in which will work an endless and reversible (for the purpose of loading barges at either end in the future) belt conveyor, 250 tons per hour, at 260 ft. per minute, delivering at the east end on one of a series of belts conveying the coal into retort houses some 600 yards distant or to the storage ground of 40,000 tons. The coal will be reclaimed from store by means of an 8-ton electrically-driven crane. Large reinforced concrete purifiers are also being constructed. All the complete new plant referred to in the description to which the attention of readers has already been directed has had to be erected on the very limited ground area which was at disposal after pulling-down existing small plant, and the usual manufacture at the station has had to be carried on during the reconstruction, alterations to mains, &c.

As much time as was available was naturally devoted to the carbonizing plant; the reconstruction of No. 1 retort house having been in hand during the past eighteen months. There are sixteen settings of eight Glover-West vertical retorts, built to produce 7 million c.ft. of gas in 24 hours, carbonizing 450 tons, at 79 therms per ton. The retorts are of the Leigh type; and the settings are fully equipped with waste-heat boilers. In the retort house a full set of drawings of the installation were displayed. These drawings included arrangement drawings of the installation as a whole, together with a set of detail drawings of the retort settings and of the working parts of the plant. These detail drawings will be handed over to the engineers in charge of the operation of the retort house. They are fully marked with reference numbers, by which every moving and renewable part can be identified—thus greatly facilitating repairs and renewals when such become necessary. It may be mentioned that coal is weighed automatically when entering the retort house, while on the belt conveyor; while coke is also weighed automatically before being charged into the producers.

On reaching the new stove shops, most welcome and most bounteous hospitality awaited the visitors—most of whom by that time showed evident signs of having borne the "heat and burden" of the day. Mr. Solomon then explained the cause of the regretted absence of the Governor and the Chief Engineer. He remarked that the Institution, already a great body, promised in the future to be of still greater importance. They as members should honour those gentlemen who, within recent years, had brought the Institution to the position which it now occupied. So far as the Fulham Station was concerned, it had been a great anxiety to them to get the place into a fit state for the visit. Fulham had always enjoyed the reputation of being neat and tidy; but this was doubly hard to maintain with

VIEW OF THE STATION FROM THE AIR.

so much reconstruction work on hand. He hoped that what they had seen had proved of interest to them. Mr. Samuel Glover, in terms which met with the approbation of all present, voiced their thanks to the Governor and Directors of the Gas Light and Coke Company for their invitation to visit the works, and for the hospitality that had been extended to them. He also made graceful and well-deserved acknowledgment of the attentions of Mr. Solomon and the services of the guides. Notwithstanding what had been said by Mr. Solomon as to the conditions of the works, he could assure him of the great joy experienced by gas engineers in visiting a works under reconstruction. Mr. Hubert Pooley seconded the vote of thanks, of which Mr. Solomon made suitable acknowledgment.

DESCRIPTION OF THE WORKS.

This station was one of the original works of the Imperial Gas Company, which amalgamated with the Gas Light and Coke Company in 1876. At that time the Engineer of the works was Mr. E. Kirkham, who was the designer of the station as it then existed.

Site.—The site covers an area of 29½ acres, and in part adjoins the North Bank of the Thames a short distance above Chelsea Railway Bridge. A creek from the river, terminating in a dock, enables coal barges—loaded at the Company's Beckton Works—to be unloaded by three wharf-side cranes. The works is also connected by direct siding with the West London Extension Railway; and coal, bricks, and other goods can be received by this means.

The tar, liquor, and oxide of iron are all sent away, for working up, by barge to the Company's Chemical Works at Beckton.

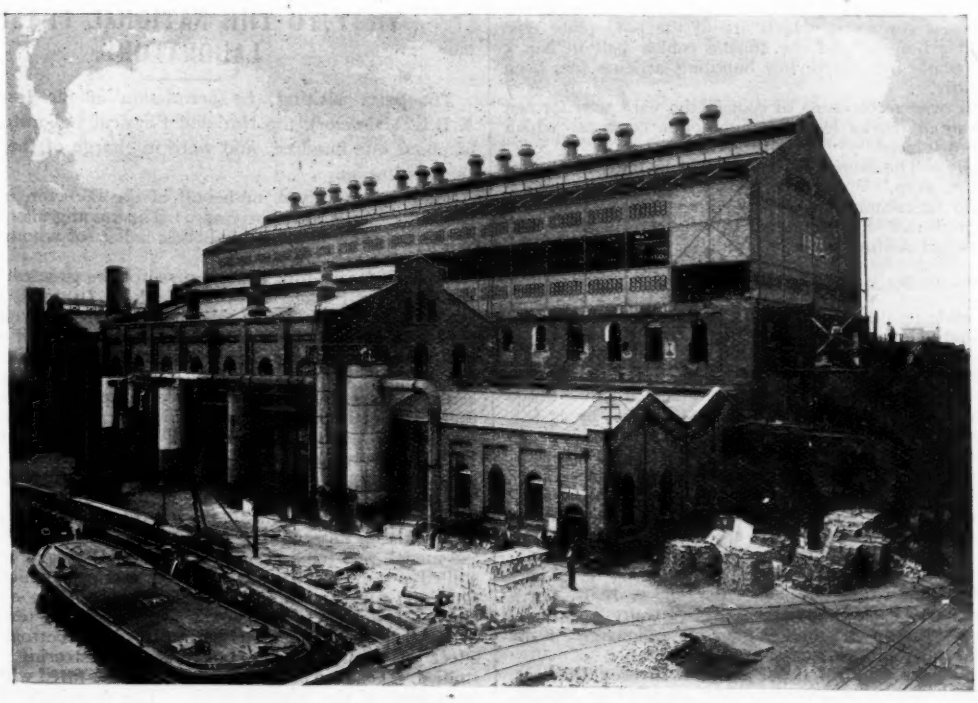
Capacity.—The works has a present daily winter output of 10½ million c.ft., but the extensive reconstructions now nearing completion will raise this to over 17 million c.ft. daily. At the same time improved means of coal reception, so as to unload direct from the Company's own colliers, are being installed upon the river front.

Existing Plant.

Coal Gas Plant.—No. 3 retort house contains 200 retorts, 23 in. by 16 in. by 20 ft. long, in 20 beds operated by a Fiddes Aldridge machine. The house carbonizes 230 tons daily, and produces therefrom 3 million c.ft. of gas.

No. 4 retort house contains 144 inclined retorts in 18 beds. It is not much worked at present, but will make 2 million c.ft. daily.

No. 5 retort house is similar in type to No. 3, but the retorts



CARBURETTED WATER GAS AND VERTICAL RETORT HOUSES

are 22 ft. long. The Fiddes Aldridge machine is of the latest type. The house carbonizes 250 tons of coal, and produces 3,250,000 c.ft. of gas daily.

In all three houses, coke handling is by drag-bar conveyors into outside loading hoppers.

Water Gas Plant.—This plant, together with the attendant boilers, blowers, and other machinery, is housed in one row of buildings adjacent to No. 1 retort house. It consists of two twin-generator Humphreys & Glasgow carburetted water gas units, each of 1½ million c.ft. daily capacity, and one Humphreys & Glasgow 1½ million c.ft. daily capacity blue water gas unit. All three sets are equipped with waste-heat boilers, stage clinkering floor, and, subsequent to the present reconstruction, will have mechanical coke handling plant.

Exhausters.—These are housed in one building. There are eight sets, seven of which are by Messrs. Gwynne & Co., and one by Messrs. Waller & Co. The house also contains a Reavell positive booster driven at 800 r.p.m. by a 90-H.P. motor.

Ammonia Plant.—At the rear of the exhauster house is the ammonia purifying plant. The gas is exhausted before passing through the condensers. There are two sets of atmospheric, and two sets of water-tube (Clapham), condensers. These are followed by three sets of washing plant, each consisting of one Livesey washer and one rotary washer-scrubber. From this point the gas passes across the works by two 24-in. mains to tower scrubbers, where the last traces of ammonia are arrested.

Purifiers.—There are four sections of purifiers. The two of more recent construction, allocated to coal gas, are luteless boxes arranged overhead, and each section consists of five boxes. Each box measures 48 ft. by 30 ft. by 6 ft. 6 in. deep, and has a capacity of 130 tons of oxide when laid in two tiers on wooden grids.

The two remaining sections for water gas are of old design, and have counterbalanced water-luted lids. Each section is worked in two streams of three boxes. Each box measures 37 ft. by 20 ft., and holds 70 tons of oxide. The coal gas, before entering the station meters, is washed with gas oil, for the removal of naphthalene.

Station Meters.—There are three meters, two of 250,000 c.ft. per hour for coal gas placed partly below ground, and one of 150,000 c.ft. per hour for water gas. All are in the open.

Holders.—There are five holders of a total capacity of 8¼ millions. One 2 million c.ft. holder has been removed recently for reconstruction. All have brick and puddle tanks.

Electric Generating Plant.—All the current at present required on the works is generated in the room adjoining No. 3 retort house by means of two 150-KW. vertical gas engine driven sets, producing 220 v. direct current. Three smaller units have been removed recently to make room for more modern and enlarged plant, described later.

Steam Plant.—Apart from the water gas plant, all steam required is produced at 120 lbs. per sq. in. pressure in a range of six hand-fired Lancashire boilers of the Thompson dish-ended type, 30 ft. long by 8 ft. 6 in. diameter. The furnaces are all of forced-draught breeze-burning type, and the fuel is to a large extent mechanically handled.

Coal Handling Plant.—At the present time coal is brought in barges into dock, and unloaded by grabs. It is then conveyed by belts to a central crushing plant, and distributed therefrom to the several retort houses by belt conveyors, and thence to the bunkers by house conveyors which are of the push-plate type in Nos. 3 and 4 houses, and the shuttle rubber belt in No. 5 house. The whole belt conveying handling scheme has been installed recently.

The store of over 20,000 tons of coal in the yard was formed by means of small trucks fed by a push-plate conveyor which has now been displaced.

Water Supply.—The deep well, constructed in 1907, is a 12 in. borehole, 501 ft. deep. Water is raised by a 75 H.P. gas engine driven Reavell air compressor, or alternately by an Alley and Machellan compressor direct coupled to a 65 H.P. motor. The plant is capable of dealing with 8000 gallons per hour.

Reconstruction Work.

This work embraces the erection of a complete plant throughout for the production of 7 million c.ft., or 35,550 therms, per day.

No. 1 Retort House.—The reconstruction of this house has been in hand during the past 18 months. There are 16 settings of eight Glover-West vertical retorts (33 in. by 10 in. by 25 ft.), built to produce 7 million c.ft. in 24 hours, carbonizing 450 tons at 79 therms per ton. The retorts are of the Leigh type, and the settings are fully equipped with waste-heat boilers.

Condensers.—A battery of atmospheric condensers, erected by the Company, consisting of 12-in. zigzag pipes, is supplemented by two water-tube condensers erected by Messrs. W. C. Holmes & Co., of Huddersfield.

Exhauster House.—Nearby, a smaller building originally used as a lobby and store has been enlarged, to house three Donkin exhausters, each of 175,000 c.ft. capacity per hour. The building also houses a small Waller air exhauster for the purifiers, and sundry pumps for tar and liquor.

Washers.—For tar removal there are two Livesey washers, each able to deal with 3½ millions per day, supplied by Messrs. Cockey & Sons. For ammonia extraction there are two rotary washers, each of 7 million c.ft. per day capacity, built by the Whessoe Foundry Company.

Purifiers.—Reinforced concrete purifiers are being constructed nearby. The boxes are elevated above ground. There will be two sections of four vessels, each vessel measuring 50 ft. by 35 ft. by 6 ft. 6 in. Above, there will be a revivifying floor, to which the oxide will be raised by an elevator, and distributed, after passing through a disintegrator, by a belt conveyor. The ferro-concrete is being constructed by Concrete Piling, Ltd., the oxide handling plant by Messrs. R. Dempster & Sons, and the steel covers by Messrs. E. Cockey. The cast-iron mains and connections, supplied by the Stanton Ironworks Company, will be fixed by the Company. These and the mains in the exhauster house are the only ones under the ground. The remainder, of steel, will be run upon supports overground.

Meters.—There are two meters, each of 250,000 c.ft. per hour capacity, by Messrs. Parkinson & Co., erected in an old gasholder tank. An additional 36-in. main from meters to gasholders has been installed to handle the gas from this new plant.

No. 4 Gasholder.—The demolition of this is just completed. It was built in 1856, and was in excellent preservation, but was removed in order to obtain further storage capacity. Messrs. R. & J. Dempster, Ltd., are the Contractors for the erection of a four-lift spiral-guided holder of 4 million c.ft. capacity, which is double that of the former holder in the tank.

Water Tower.—Owing to the building of the new purifiers upon the site which included the water supply tank to the works, it has been necessary to provide a new tank. This has been constructed in reinforced concrete, to the Company's design, by Concrete Piling, Ltd., upon a site by the railway siding. Its capacity is 60,000 gallons, and it is 77 ft. high.

Coal Plant.—At the river front the quay wall is being strengthened by the driving of 35 ft. concrete piles (Contractors, Messrs. Saxild & Partners) for the purpose of supporting two electric cranes (capacity, 7½ tons maximum load) and to enable a berth to be provided for the ships. The coal will be unloaded into a reinforced-concrete bunker (capacity, 2000 tons), from which it will be conveyed by belts to a crushing station, and thence to the retort houses—a total distance of 600 yards—or to the storage ground, at the rate of 250 tons per hour. Coal is reclaimed from the stock heap by an 8-ton travelling crane with a 60 ft. luffing jib at 150 tons per hour, and delivered to the belt conveyor system. The conveying plant and stocking plant are being erected by the Mitchell Conveyor Company.

Electric Generating Plant.—To provide further power, and at the same time effectively to utilize the steam from the waste-heat boilers, in the power house there is in the course of erection one 500 KW. D.C. 220-240 v. turbo-generator and condenser, and one 250 KW. A.C. 500 v. 3-phase 50-period turbo-generator and condenser, together with an air pump for each set, and circulating pumps in duplicate, switchgear, &c. In addition a motor generator has been installed as a connecting link between the A.C. and D.C. supply. The alternating current is arranged for the long-distance coal plant supply, and the direct current for the more local supplies. The Contractors for this plant are the Lancashire Dynamo Company, Ltd., who are supplying turbines built by Messrs. C. A. Parsons, Ltd.

VISIT TO THE NATIONAL PHYSICAL LABORATORY.

The party visiting, by permission of Sir Joseph Petaval, K.B.E. (Director), the National Physical Laboratory, consisted of about one hundred, and were in charge of the Secretary of the Institution.

They were received, on behalf of the Director, by Mr. G. R. Edwards, Assistant Secretary. The arrangements made for conducting the members and their ladies (of whom there was a good number) were perfect.

Perhaps the feature which proved of the greatest interest was the William Froude National Tank. In 1908, by a gift of £20,000 from Sir Alfred Yarrow, Bart., the well-known torpedo-boat builder of the Clyde, the construction of the tank was commenced. Completed in 1911, it consists of a concrete tank 550 ft. long, 30 ft. wide, with a depth of water of 12½ ft. in the centre. Experiments on models of ships are carried out with the object of improvement in ship design and propulsion. The models are made of paraffin wax in a special cutting machine with flying cutters which reproduces exactly the lines of the ship as designed by the naval architect. By means of a spokeshave, the model is finished-off carefully by hand. It is placed on the bed of the machine with the keel uppermost. The apparatus for determining the water resistance to the motion of the model, and for making other required measurements, is installed on an electrically-propelled carriage which spans the tank and runs on rails laid on either side. The equipment includes apparatus for producing waves so that tests of models in rough water can be carried out. A false bottom enables the effect of shallow water on resistance, steering, &c., to be studied. Tests on propellers and on models fitted with propellers, form part of the routine work. The drawings of a ship received on (say) Monday morning can be worked upon, the model

produced and tested, and a report of its performance sent to the client, if needs be, on the Saturday following. A test costs £140 to carry out; but it is quite possible that the reduction of horse-power resulting from the disclosure of the tests may save that amount in the cost of fuel in one voyage of the ship itself.

The experiments are supplemented by full-scale observations on the ships themselves. The Suez Canal has been visited to study the effect of shallow water on the steering of actual ships, and voyages have been made in rough weather to obtain data relating to the motion of ships in waves, for comparison with the conclusions derived from the researches conducted in the tank.

Another department which attracted considerable interest was the Sir Julius Wernher Metallurgy Building, the gift of Sir Julius in 1911, to advance the science of metallurgy. The workers here deal with the physical and mechanical properties of metals and alloys, in which the proportions of the different constituent metals are varied over a wide range. Aluminium-copper, aluminium-copper-nickel, aluminium-copper-manganese-silicon, &c., have been examined, as also the effect in the production of such alloys for practical use, of different heat and mechanical treatment, and the various processes which must be employed in the application of the materials to constructional purposes. Microscopic and X-ray examinations of and structure of the metal or alloy to mechanical, thermal, and electrical tests of the resulting products are carried out.

The physics, electricity, metrology, and engineering departments were also seen, and in the aerodynamics department was shown the method of testing aeroplanes, propellers, &c. It was formed in 1909 at the invitation of the Government.

Tea was served at the conclusion of the visit in the spacious canteen. There were flowers, grown on the premises, for the ladies. A vote of thanks was proposed by Mr. C. Dru Drury, member of Council.

THE INSTITUTION AT OLD KENT ROAD.

Visit to the Chemical and Physical Department of the South Metropolitan Gas Company.

PERHAPS the best indication of the remarkable interest of the visit of a section of the Institution of Gas Engineers to the Chemical, Physical, and Industrial Laboratories of the South Metropolitan Gas Company at Old Kent Road was that, almost before one had realized the fact, the visit was concluded, and one was returning to Westminster. And yet the tour of inspection had lasted two-and-a-half hours—and this on an afternoon when the thermometer registered 87 degrees in the shade!

Motor coaches conveyed the party, which numbered about a hundred, from the Institution of Civil Engineers to the Old Kent Road Station of the Company. The weather was delightful, and even Old Kent Road was robbed of its customary drabness. On arrival at the works, the visitors were divided into small parties, and without delay commenced an inspection which proved to be, as Mr. C. F. Botley, the new President of the Institution, so aptly described it, a "real intellectual treat."

THE CHEMICAL SECTION.

This was visited first. On entering the laboratories, one is immediately impressed—and the impression is enhanced by closer inspection—with the general note of cleanliness. There is that atmosphere of orderliness which makes for proficiency.

Attention was first of all drawn to an apparatus for carrying-out trial carbonizations for determining the effect of temperature, rate of heating, physical and chemical nature of coal, &c., upon the yield and nature of products obtained. Specimens of coke and tar obtained in this apparatus showed the effect of different rates of carbonization; and other specimens of coke demonstrated the effect of blending different materials with the coal for the purpose of avoiding expansion. Specimens of briquettes of 70/30 coal-coke mixtures, carbonized at high and low temperatures, and exhibits showing the effect of the size of particle upon the nature of coke obtained from coal-coke mixtures next claimed attention. The visitors passed on to examine an apparatus used for comparison of the activity of various catalysts in connection with the removal of carbon bisulphide from gas. It was explained that the best results are obtained from a nickel-thoria catalyst; the velocity of the reaction with this compound being two or three times as great as with the original nickelized fireclay. There was also a model of a sulphur extraction plant for testing-out modifications suggested from the results of investigations on the small scale in the laboratory. It is not possible here to detail all the interesting exhibits, which evoked the praise of the visitors from two points of view—the intrinsic value of the exhibits themselves, and the excellent way in which they were set out.

On the subject of the removal of hydrogen sulphide from gas, there was a demonstration of the methylene blue test for the quantitative determination of minute traces of hydrogen sulphide. This colorimetric test is based on the interaction of hydrogen sulphide with dimethyl-*p*-phenylenediamine and ferric chloride in acid solution, to give methylene blue. The hydrogen sulphide is primarily absorbed in ammoniacal cadmium chloride solution and liberated for the reaction by the addition of acid. Nearby was an apparatus for introducing measured traces of hydrogen sulphide into coal gas, and demonstration thereby of the sensitivity of the Referees' testing apparatus. There were exhibits demonstrating the causes of the occasional contamination of completely purified gas by hydrogen sulphide upon storage in gasholders; and the bacterial origin of the hydrogen sulphide, and its suppression by the use of sterilants.

TAR FOR ROAD SURFACING.

One of the most interesting features in the Chemical Section was a well-planned and convincing demonstration that tar suitably treated could be applied to roads without endangering fish life—a subject which of late has received much publicity.

Explanation was given of the systematic tests of tar for fluidity or viscosity, volatilization, binding power, and resistance to compression and recompression; and there was a demonstration of a disinfectant fluid prepared by an emulsifying agent, which, unlike soap, gives a product unaffected by hard water.

The visitors passed on to examine an apparatus for determining volatile matter in coal under conditions more precise than those laid down in the so-called "American Test." Another highly interesting item was an apparatus for determining the ignition point of coke.

A demonstration of corrosion specially dealt with the corrosion of gasholders in which metallic surfaces are brought into contact with water. The galvanic nature of such corrosion was demonstrated, together with the possibilities and limitations of methods of preventing it.

INDUSTRIAL SECTION.

General admiration was expressed of the Industrial Demonstration Laboratory. This constitutes a general exhibit of industrial appliances, furnaces, &c., which have either been designed and erected to meet the special requirements of consumers, or have recently been submitted for examination. In this exhibit are included muffle and crucible furnaces, fish-frying ranges, apparatus for the manufacture of confectionery, and various types of industrial burners. The value of such laboratories is becoming more and more appreciated; and several of the larger undertakings in industrial centres have come to regard them not merely as desirable, but as essential.

In the Burner Workshop the visitors were able to see the production of ejector discs. Orifices of standard dimensions are produced in discs of nickel alloy, which are simultaneously cut from the sheet metal by specially designed machines. In order to produce smooth passages for the efflux of gas, the discs are burnished by hand. They are then mounted in seatings cut in the disc-holder, and are spun, so as to ensure that no leak can occur between holder and ejector disc. The orifices are tested to ensure that the jet of issuing gas will be directed axially down the burner tube. For this purpose a jet of gas issuing from the ejector orifice is ignited, and the ejector rotated about its axis. Any departure of the stream of gas from an axial direction is clearly seen. A system of limit gauging for the standardization of all component parts was demonstrated. These standardized parts are assembled into a burner which is examined for symmetry, alignment, &c. The assembled burners are placed on a bar supplied with gas at a pressure of 25 tenths water-column, and each burner is lit for a period of half-an-hour, and the character of the flame in each burner visually examined. Burners exhibiting defective flames are rejected. The consumption of each burner is determined in order to ascertain that it falls between specified limits. A similar procedure of standardization and examination is applied to the production and assembling of gas fires, and street lighting, high-pressure, and cluster burners.

PHYSICAL SECTION.

Arrived at this Section, inspection was first made of the photometer room. This is equipped with a photometer bench enabling the radial distribution of illumination from sources of high or low candle power to be carried out expeditiously. A complete survey of any source occupies about half-an-hour. An incandescent mantle, standardized against the Harcourt pentane 10 c.p. lamp is employed as a secondary standard. The bench was shown equipped for the measurement of the radial distribution of illumination from a street lamp in which reflection is utilized to effect concentration of considerable illumination in directions approaching the horizontal.

Illumination by a "Daylight" mantle was compared with that given by an ordinary mantle; and the determination of the intensity of various parts of the spectrum of a "Daylight" mantle by means of the Hilger-Nutting spectrophotometer was shown.

Very interesting was the comparison of noises made by various gas jets and burners. A number of triode valves are employed to amplify and rectify a microphonic current pro-

duced by the noise. The microphone employed is of special design; and the sensitivity of the microphone and amplifier is practically constant for all wave lengths. The galvanometer deflection produced thus depends only on the intensity of the sound incident upon the microphone diaphragm.

Of particular interest was a high-pressure gas governor. A constant pressure is maintained within a cylindrical chamber closed on one side by a diaphragm. Any variation of pressure occurring on the outer side of the diaphragm opens or closes a paraboloidal valve, whereby constancy of pressure is maintained at the outlet from the governor. The device can be employed to construct governors operating either at high or low pressures, and was shown operating at a pressure of about 15 lb. per sq. in.; this being maintained constant at an orifice through which air at this pressure was discharged while the supply pressure varied from about 20 to 70 lbs. per sq. in. The discharge was utilized to illustrate the deficit of pressure occurring in a jet of gas—a phenomenon to which the collection of dust round the jet orifice is attributable.

Before concluding this brief and inadequate description of the exhibits, we will refer to a directional form of hot-wire anemometer. Two fine heated wires are arranged in close juxtaposition in the flow tube. The wire upon which the flow is first incident experiences the greater cooling effect—in fact, for slow flows the second wire may experience a heating effect, attributable to the transport of heat from the first wire. The differential effect is utilized to indicate the direction of flow in the system.

Thanks to Dr. Carpenter and his Staff.

After the inspection the party assembled in the Staff Dining Hall, where tea had been provided.

Mr. C. F. Botley said it would be inappropriate if they did not voice their thanks to Dr. Carpenter and his staff for what had proved a real intellectual treat. The standard of working which the South Metropolitan Company set was well known to them all; and they had enjoyed the opportunity of seeing how this standard was kept up. They had been able to appreciate how the Company were investigating problems of vital importance; and they would all be glad to hear that Dr. Carpenter had told him that the Institution of Gas Engineers could have the benefit of the information accruing from the research in the Company's laboratories. [Applause.] He had known the South Metropolitan Company all his life, and it had always been a source of inspiration to him. He had the greatest pleasure in proposing a vote of thanks to Dr. Carpenter and his staff. If those present only remembered a fraction of the information which they had gained through the visit, they would benefit exceedingly.

The vote of thanks was seconded, and carried with acclamation.

Dr. Carpenter, who, on rising, was greeted with prolonged applause, said he was very gratified with such a warm reception on such a warm afternoon. The Institution, as a result of their inspection, had received a mental picture which they should register carefully. Work of a character analogous to that carried out in the laboratories of the South Metropolitan Company was being undertaken by the electricity industry, who were busily investigating the various phases of the use of electricity for heating and lighting. They were dealing with such questions as the efficiency of electric lamps, the influence of inert gases, the effect of bulb shape, and a hundred and one other matters which were essential and which played such an important part in the progress of that industry. Day after day and week after week this type of research work was being done in the laboratories of the British electricity companies; and it was this work which had paved the pathway of progress in the electricity industry. He ventured to say that the gas industry, in spite of the good work done by its various societies, was not in such a fortunate position. For example, research in gas mantles was in the main left to the manufacturers, who did not regard their work with the broad outlook necessary for full efficiency from the gas industry's point of view. The same thing applied to the efficiency of fires, and so on; and he very much regretted the imperfection of this position. One of the experiments which the visitors had been able to see was concerned with particles of dust and their effect on a gas burner. To this end a balloon had been used effectively. They might ask: Why bother about dust? Well, it was by no means uncommon to find that small craters of dust particles had grown round the little holes in the burner injector; and in course of time these prevented the proper flow of gas, and reduced its momentum and pressure. The experiments carried out by Dr. Thomas had enabled them so to modify the construction of their burners as to minimize the chance of dust blocking-up the injector. Another point he would mention was the production of a tar suitable for use on roads. They had determined the characteristics of bitumen which were alleged to make this material particularly suitable for road surfacing, and these, if further experience showed them to be desirable, could be reproduced in the coal tar product. One of the major difficulties experienced was that roads were often treated with tar in a very unscientific manner. Then they had to deal with the prejudices of the public on the question of the pollution of streams as a result of using tar on roads. The South Metropolitan Gas Company were producing a tar which had not the toxic effect on fish which ordinary tar had. He would also refer to the important question of modern methods of gauging the different parts of appliances, to ensure accurate interchangeability. It was still quite a common experience to have deliveries of pipe of one stated diameter in which the different threads had not the same diameter. Standardization of plugs, taps, &c., had to be done in a more satisfactory manner. In regard to wrought-iron and steel barrel, it was a fact that in some parcels they found 75 p.ct. of steel and 25 p.ct. of wrought-iron pipes; and the number of pipes rejected in twelve months was enormous. They were endeavouring to instal only wrought-iron barrel for both external and internal services, for it was, he thought, generally recognized that wrought iron was preferable to steel. There was much to be done to perfect the efficiency of gas supply. To mention another thing, all appliances should have accurately fitting and gas-tight taps. The South Metropolitan Company had set themselves definite standards of mechanism, manufacture, and accuracy. On behalf of the staff and himself, he thanked them most sincerely for their expression of appreciation.

Motor coaches were in readiness to convey the visitors back to Westminster; and on all sides one heard expressions of appreciation of an afternoon well spent. Once again the South Metropolitan Gas Company had given expression to their underlying motive—progress through efficiency. Memories of the highly interesting visit will not be readily effaced.

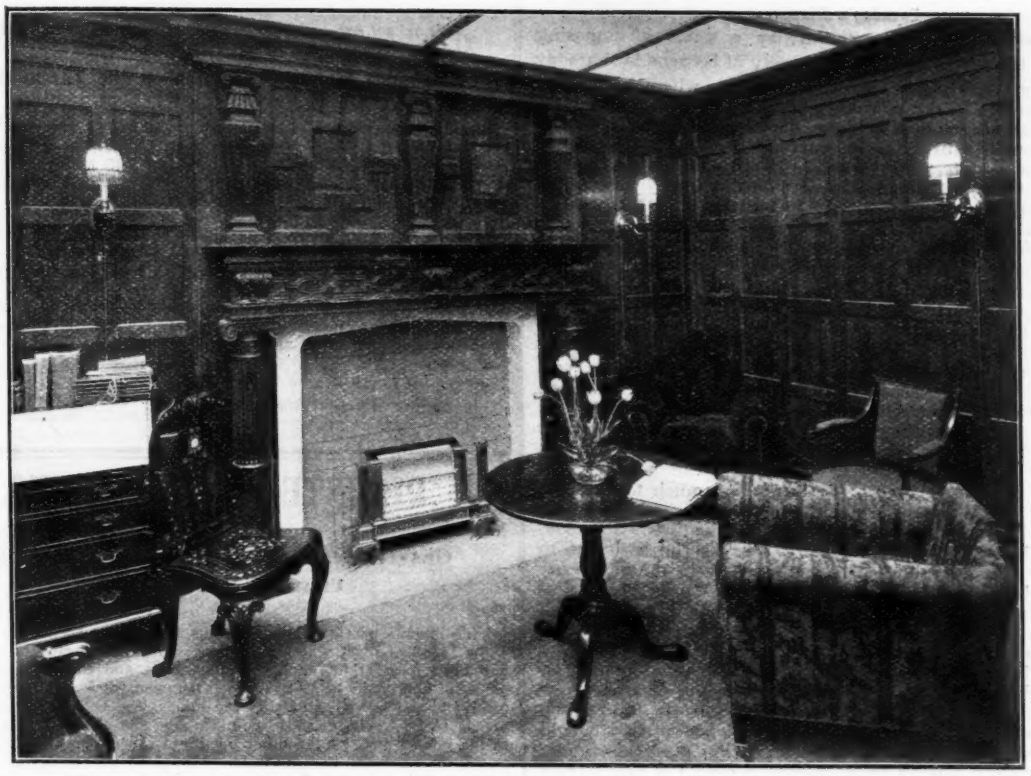
Electrical Manufacture of Carbon Black.

Indicating the lines of suggested improved apparatus for making carbon black from gas oil, kerosene, or other liquid hydrocarbons, Mr. J. J. Jakosky, of the United States Bureau of Mines, says, in Technical Paper, No. 351, that the oil would be placed in a suitable storage tank, and then pumped to counter-current gas scrubbers. From the header the oil would flow down through the scrubbers into the treating chamber. After passing through the arc or treating chamber, the treated oil would flow to a settling tank. In the settling tank the clear oil would gradually rise to the top, and pass out through an overflow, either back to the original storage tank or to stills for re-distillation. The carbon from the settling tank could be drawn out near the bottom, in the form of a sludge, and then treated. The gas produced during the decomposition of the oil in the arc chamber would be passed through the scrubber, counter-current to the incoming oil, and out of the gas outlet at the top of the header. This gas coming from the arc chamber contains a large amount of carbon in suspension; and it was found that thorough scrubbing was necessary in order to remove it. In order to aid the scrubbing process, it might be beneficial to have the entire system under pressure, in which case the pressure valve at the top of the header could be adjusted. The effects of pressure upon the carbon formation are not known; but to Mr. Jakosky it seems probable that a high pressure would tend to keep the oil in closer contact with the arc, prevent much volatilization of the oil, and thereby ensure higher efficiency. For manufacturing carbon black by the process described, the main essentials are cheap electric power and cheap light-oil distillates.

Fire at a Meter Works.—Damage estimated at several thousands of pounds has been caused by a fire at the works of Messrs. George Wilson Gas-Meters, Ltd., in Foleshill Road, Coventry. Three departments were gutted, and some damage was done to other portions of the premises and stock; but owing to the prompt work of the employees and the city fire brigade, the main building was saved. The cause of the outbreak has not been ascertained; but it is supposed to have been due to the heat of the sun acting upon the contents (straw and similar material) of a corrugated iron packing shed, situated on land adjoining the factory. At any rate, it was here that the conflagration originated.

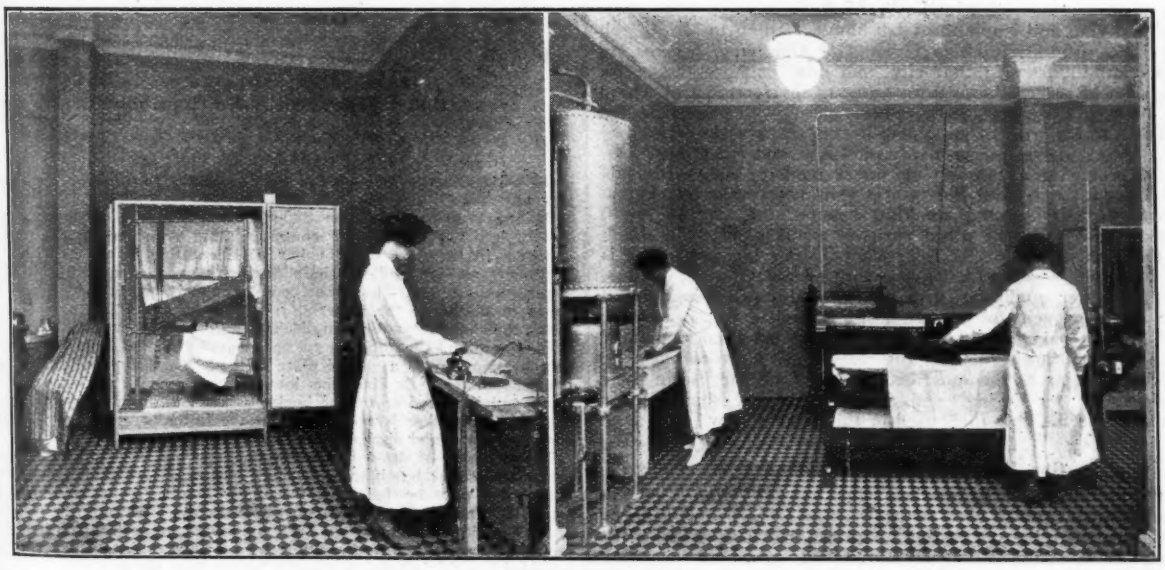
Luton Gas Company Shares.—Last week Messrs. Cumberland & Sons, Auctioneers, offered at Luton 2000 new ordinary shares, class F, of £10 each, for sale on behalf of the Luton Gas Company, and described them as the "only local gilt-edged security." The standard dividend on these shares is 5 p.ct. per annum, but they are on a sliding-scale dependent on the price of gas, and for the past two-and-a-half years the dividend has been 8¼ p.ct. This new issue is made to provide capital for extensions of the undertaking, which has increased its output by more than 100 p.ct. in 18 years. The shares were offered in lots of two, five, and ten; each buyer of a lot having the option of taking the four following lots. A number of the earlier lots were sold at £13, but as the sale proceeded the price fell successively to £12 17s. 6d., £12 12s. 6d., and £12, which then became the standard. When the sale was adjourned, more than half the issue had been disposed of, and further sales at the £12 figure have since been made privately.

THE GAS EXHIBIT AT WEMBLEY.



THE WEMBLEY CLUB ROOM OF THE SOCIETY OF WOMEN JOURNALISTS IN THE ADMINISTRATIVE OFFICES OF THE GAS EXHIBIT.

The room is placed at the disposal of the Society by the Gas Exhibit Committee as a club room and meeting place for members and their friends, both from England and from the Overseas Dominions, during the run of the Exhibition. The panelling and furnishing of the room has been carried out by Messrs. Osborne & Co., of Grafton Street.



MODEL DOMESTIC LAUNDRY IN THE GAS EXHIBIT AT WEMBLEY.

The laundry is suitable for a large house or small hotel, and is equipped with gas-heated hot water circulator, supplying the sink, low-pressure domestic gas-irons, a high-pressure gas-iron, a high-pressure "Gladiron," and a gas-heated drying cabinet.

Possibilities in Bye-Product Recovery.

Selecting some of the bye-products of coke-oven practice which appeared to him to hold out the greatest promise of successful exploitation, Mr. R. L. Robinson, in a paper before the Northern Section of the Coke-Oven Managers' Association, referred to tetra- and deca-hydronaphthalenes, which are prepared by the combination of highly-purified naphthalene and hydrogen, under pressure and at a temperature of 200° C., in the presence of a suitable catalyst. Two hydrocarbons—known technically as tetralin and dekalin—have obtained a considerable degree of importance in Germany; and a special plant for their manufacture has been erected at Rodleban, with a capacity of 120 tons per day. They are both mobile, colourless liquids, and have found extensive use as turpentine substitutes, as solvents and chemical cleansers, for new dye intermediates, and as motor fuels. Their greatest claim, however, according to the author, is as turpentine substitutes. They have been used with much success in Germany in the manufacture of paints and varnishes, although it is said that they did not give an altogether satisfactory result with white paint and enamels. In connection with these two compounds, it was pointed out in the paper that the world's output of turpentine is 30 million gallons annually, three-fourths of which comes from the United States. The demand generally keeps pace with the supply, and this being the case, there should be a ready market for efficient substitutes.

CENTENARY OF BENZENE.

Faraday's Discovery.

There was celebrated yesterday, by a series of imposing functions, the centenary of the discovery of benzene by Faraday in the laboratory of the Royal Institution, where he worked for fifty years. In the morning appreciations of Faraday were delivered at a reception held by the President and members of the Royal Institution, in association with the Chemical Society, the Society of Chemical Industry, and the Association of British Chemical Manufacturers; and in the evening there was a banquet.

The "Daily Telegraph," referring in advance to the matter, said: "Not since the Royal Institution celebrated the centenary of Faraday's birth in 1891 have the members called together a more notable gathering of world scientists; for there will be some hundreds of guests famous in the world of chemistry and the innumerable allied chemical industries. As Prof. Armstrong said at an at-home held at the Institution: 'No single subject known to chemists has had such a vast progeny of useful bye-products as benzene—as we chemists call it—or benzole as the public and motorists in particular call it. It is really the hub of the chemical dyestuff universe, which has been responsible for setting scores of chemists and investigators developing Faraday's discovery and its application to a great variety of commercial uses. It is not too much to say that since 1870 two-thirds of organic chemical research has been devoted to the study of benzene and its derivatives. Faraday, as all students know, started work here as the assistant to Davy, and succeeded him. He worked here in the laboratory continuously for some fifty years; and the very first specimen of benzene made by Faraday and labelled by him is to be seen here. Faraday had been interested in the subject from 1818 onward; but it was not until June 16, 1825, that he communicated his discovery to the Royal Society. It was, indeed, an epoch-making discovery, and Faraday lived long enough to see the production of the first aniline colour, and to foresee, no doubt, something of the enormous development that would follow his discovery. But he himself, having made his fundamental discovery, like an artist, turned in search of new worlds to conquer, and applied himself to research in electricity, in which sphere his wonderful investigations rather overshadow his earlier experiments in the production of benzene.'"

Fish Drying by Gas.

The drying and smoking of fish has, according to Mr. Joseph W. Piatt, of the Brooklyn Union Gas Company, become an important industry in that city, and now engages the entire attention of several large firms—among the foremost of whom are Messrs. Oxenberg Bros., whose plant is illustrated in the "Gas Age Record." The plant, it appears, was built in 1924 for the exclusive purpose of smoking and handling fish. It is one of the largest and most modern plants for this purpose in the United States. It contains two large smoke-houses for drying and smoking salmon, and twelve small smoke-houses for the other varieties of smoked fish. Each of these smoke-houses is equipped with gas burners. Gas is the fuel used, because of the ease with which the work is done, and the better quality it gives to the products. This installation has a capacity of 250,000 lbs. of smoked fish per week, and an increasing business is demanding an enlargement of the plant facilities in the near future. The firm are enthusiastic believers in gas as the most excellent of fuels for use in their work. Gas for drying, and wood chips and shavings for smoking are the only fuels used in this plant to-day.

Gas Favoured in Brass Foundry.

It is stated by the "American Gas Journal" that a Rhode Island foundry which used to throw away 25 p.ct. of its expensive brass and bronze castings because they proved defective when tested, changed its fuel from coal to gas. Its rejections dropped to only 3 p.ct., and at the same time operating costs were reduced and the working conditions for the men greatly improved. The firm had tried every process they could discover with coal as the fuel; but although there were certain advantages, they could not get away from the fatally high percentage of defectives. Extensive experiments were made with coke and oil; but they were not materially better. When gas was tried, the firm specified that "it must reproduce the ideal conditions of melting with coal, but have none of the objectionable features." The gas "made good." It was found that with gas a desired temperature or furnace state could be reached at will, regardless of atmospheric conditions, and that this could be reproduced exactly for batch after batch of the alloys. The gas eliminated the labour of building fires hours before the start of the work, cleaning the fires, carrying out ashes, and handling new fuel. It also did away with the smoke, dirt, and terrific heat around the furnaces, which prevented the "melter" from giving his best attention to the work. The men liked this change so much that they did more and better work.

CORRESPONDENCE.

[We are not responsible for opinions expressed by Correspondents.]

Economics of Gas Production on the Therm Basis.

Sir,—Owing to unavoidable delays, many members were unable to obtain advance copies of my paper read before the Institution on Thursday, and I find several were anxious to take part in the discussion and have further points explained, but were prevented from doing so owing to their inability to obtain advance copies and the shortness of time available for discussion.

I was able to deal with one or two queries after the meeting, and I shall be happy to answer any further points by correspondence with individual members.

I take this opportunity of writing because, after the paper, one member (whose name I have forgotten) spoke to me near the platform, and I requested him to wait a minute or so, to enable me to deal with another matter. Unfortunately I was detained much longer than the time indicated, and when I returned the particular member had gone.

George Evetts.

Palace Chambers,
Bridge Street, Westminster, S.W. 1,
June 13, 1925.

REGISTER OF PATENTS.

Gas-Heated Bakers' Ovens.—No. 233,054.

Vicars, E. L., of Earlestown.

No. 2806; Feb. 4, 1924.

This invention relates to gas ovens for baking bread, biscuits, &c. In the type of oven wherein the goods are transported on chains, it has been found that, owing to the chain and to the channel supports for the chain being interposed between the lower burners in the oven and the trays supporting the goods, the bottom surface of the article to be baked at those points above the chains is not coloured to the same degree as the other portions. It has previously been proposed to interpose baffles, which may be perforated, between the burners and the goods in order to maintain a substantially constant temperature in the oven.

The oven of the present invention has a complete perforated floor which comprises chain rails for supporting a conveyor and baffle plates situated between successive chain rails and between the outside rails and the side walls of the oven.

The baffle plates are dished, with their upper edges meeting the upper edges of the rail channels; and the perforations are so graded as to give a preferential path through the channels to the hot combustion products.

Coke Separator.—No. 233,200.

Rigby, J., of Hackney, N. 1.

No. 16,908; July 15, 1924.

This invention is for a type of coke separator working on the flotation principle.

According to the invention the apparatus comprises a water tank divided into upper and lower communicating compartments, a rotary conveyor in the form of a bucket wheel rotating in the upper compartment, and an endless chain bucket conveyor operating in the lower compartment. The upper compartment is also provided with a chute to discharge the material from the bucket wheel outside the tank; the chain conveyor also discharging outside the tank.

In operation, the mixture to be separated is fed into the upper compartment on to a slotted plate beneath the bucket wheel. The heavier clinker falls into the lower compartment, while the coke floats and is picked up by the bucket wheel and discharged on to the chute. The clinker is removed from the lower compartment by the chain conveyor and discharged.

The churning of the water by the bucket wheel assists in the flotation of the coke; but if the coke is of such a nature that it does not float, coal may be fed into the upper compartment, and cutters attached to the bucket wheel churn up the clay, increasing the density of the liquid. The buckets on both conveyors are perforated; and the material may be fed in through a rotary sieve. Suitable gearing is provided for driving the apparatus by hand or power.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF COMMONS.

The Standing Orders not previously inquired into which are applicable to the following Bills have been complied with: Blackpool Improvement, Oldham Corporation, and Uckfield Gas and Electricity.

The Bath Gas Light and Coke Company have withdrawn their petition against the Bath Corporation Bill.

European Gas Company, Ltd.—The Directors have, subject to audit, decided to recommend the payment, on Aug. 1 next, of a final dividend of 6s. per share, free of income-tax, which, with the interim dividend paid on Jan. 31 last, represents a total dividend of 5 p.ct., free of income-tax, for the year ended March 31. For the year 1923-24 a dividend of 4 p.ct., free of income-tax, was paid.

LEGAL INTELLIGENCE.

DEUCHAR v. THE GAS LIGHT AND COKE COMPANY.

HOUSE OF LORDS.—Thursday, June 11.

(*Before Viscount* CAVE (*Lord Chancellor*), *Lord* DUNEDIN, *Lord* ATKINSON, *Lord* SUMNER, and *Lord* BUCKMASTER.)

The appeal of Mr. John Lindsay Deuchar against the dismissal of his application for an injunction to restrain the Gas Light and Coke Company from manufacturing their own caustic soda for the purpose of working up residuals was considered by the Lords of Appeal on Thursday, June 11. Their Lordships, without hearing Counsel for the Gas Company, were unanimous in their decision to dismiss the appeal. (The proceedings in the High Court and in the Court of Appeal were reported in the "JOURNAL" for Jan. 23, 1924, p. 210; May 28, 1924, p. 611; and June 25, 1924, p. 911.)

Appellant was represented at the House of Lords by Mr. A. C. CLAUSON, K.C., Mr. DIGHTON POLLOCK, and Mr. J. L. MURPHY. Respondents were represented by Sir JOHN SIMON, K.C., Mr. W. A. GREEN, and Mr. A. ANDREWES UTHWATT.

Mr. A. C. CLAUSON, K.C., opening for the appellant (who is Secretary of the Castner Kellner Alkali Company, Ltd.), said that, as a holder of a small sum of stock in the Gas Light and Coke Company, he was bringing an action against them with a view to testing the limits of the powers of the Company. Though the action was brought by the appellant as a holder of stock in the Company, Counsel said that he did not wish for a moment to conceal the fact that the action was brought in the interests of certain traders, who took the view, rightly or wrongly, that the Company were exercising certain activities which they were not authorized to exercise. The question to be decided was purely a matter of the construction of the Acts which regulated the Company. The facts, in substance, were not in dispute. The Company had erected a factory for the manufacture by the electrolytic process of caustic soda required for the purpose of treating their naphthalene, and the erection of that factory was not within the powers of the Company. Counsel went on to explain that the caustic soda was to be used for converting naphthalene into beta-naphthol, and that the manufacture of caustic soda by the electrolytic process produced chlorine as a bye-product. Neither caustic soda nor chlorine was a residual of gas. The chlorine was got rid of by turning it into bleaching powder, which latter the Company sold. Counsel pointed out that with caustic soda and chlorine one could make an enormous number of saleable combinations.

Counsel then quoted at length from the evidence given in the lower Courts with regard to the manufacture and uses of caustic soda and chlorine.

Lord BUCKMASTER, having obtained the admission from Counsel that the Company were competent, within their Charter, to convert naphthalene into beta-naphthol, said he understood the appellant's case was that they must not produce the caustic soda for that purpose, but must buy it elsewhere. He pointed out that the Company had not sold the caustic soda they had made.

Mr. CLAUSON said his case was that the Company could not manufacture it.

The LORD CHANCELLOR said that, assuming the Company were entitled to manufacture caustic soda for treating residuals, they could not do this without incidentally producing chlorine. There was no evidence to show that the chlorine had been used for treating other residuals, but there was evidence that it might be so used. Assuming they did not use it for treating other residuals, could they not produce it?

COUNSEL replied that what the Company did was to get rid of the chlorine by setting-up another plant, and producing another thing altogether.

The LORD CHANCELLOR pointed out that they must get rid of the chlorine.

COUNSEL said his argument would be based on the fact that the Company were given express powers to manufacture various things, but none of the things included caustic soda.

Coming to the relevant sections of the Company's Acts, Counsel dealt first with section 40 of the Act of 1868, which stated that the Company may "make and store and supply gas, and may convert, manufacture, and deal with, sell, or dispose of, coke, tar, coal, pitch, asphaltum, ammoniacal liquor, oil, and all other products, refuse, or residuum arising, remaining, produced by, or obtained from, the making by them of gas, or the materials used therein, and may make and sell all articles produced from, or by means of, those several matters, . . ." His contention was that there was nothing there that could possibly be suggested as authorizing the manufacture of caustic soda.

Lord BUCKMASTER said there was nothing which expressly conferred upon the Company the right to manufacture the reagent used for the conversion of naphthalene into beta-naphthol, but whether or not it was implied was a matter to be determined.

COUNSEL'S submission on Clause 40 of the 1868 Act was that it was a very strong line to seek to find in that clause, by implication, a power to manufacture something which was not named.

Lord ATKINSON said there was no power for the Company to manufacture electricity, but yet it might be a reagent for dealing with residuals.

COUNSEL replied that, as a matter of fact, the Company did generate their own electric power.

Lord ATKINSON asked whether the argument would not be the same in that case.

COUNSEL said he was by no means prepared to say that it was within the power of the Company to generate electric power.

Lord BUCKMASTER pointed out that the object of the Statute was to give the Company limited powers of trading. Was it not also to enable them to do all things necessary for the purpose of efficiently carrying on that trade?

COUNSEL said it was.

Lord BUCKMASTER asked why, if it were necessary for the efficient carrying on of the trade that they should provide themselves with this reagent cheaply, instead of buying it from outside, the Company should not do it. If they were selling caustic soda outside, it would be quite a different proposition, but they were providing it for the purpose of their undertaking.

COUNSEL replied that their Lordships were basing the power to manufacture caustic soda on something which was implied by reason of the power given to carry on another process in the most advantageous and satisfactory way. The point was that, if they could get it perfectly well without manufacturing, why manufacture it, when their powers of manufacture were expressly limited?

Lord BUCKMASTER, in the course of discussion, said it was not unlikely that what the legislature meant was this. Having given the Company power to make gas, unless they also gave power to manufacture things necessarily resulting from the manufacture, the Company would not be able to make the gas. Therefore, they had given the Company power to make things resulting from the manufacture of gas. The Company could convert and make, deal with and sell, all those products arising from the making of gas, as mentioned in Clause 40 of the 1868 Act, and could make and sell all articles produced from, or by means of, those several matters. This must mean something more than the making and selling of the things which were mentioned, and, therefore, it must mean that they might make and sell all the things necessary for the conversion of those products.

JUDGMENT DELIVERED.

Judgment was delivered in favour of the Gas Company without their Counsel being called upon to respond to the arguments put forward on behalf of the appellant.

The LORD CHANCELLOR, in his judgment, said that, notwithstanding the careful and complete argument addressed to their Lordships on behalf of the appellant, he did not feel any doubt as to the correctness of the decision of the Court of Appeal in this case. The respondent Company, the Gas Light and Coke Company, was formed by Statute for the purpose of making and selling gas; and in the course of making gas from coal, the Company necessarily produced a number of residual products. It was obviously undesirable that these residuals should be wasted if they could be so dealt with as to acquire a money value, and it was not disputed that the Statutes under which the respondents acted authorized them to convert these residuals into a marketable state. In a reference to the production of naphthalene and its conversion to beta-naphthol, he said the conversion was best effected by the use of caustic soda, and the respondents did convert their naphthalene into beta-naphthol in that way. For a time they had provided the necessary caustic soda by purchase, but recently they had commenced, presumably for purposes of economy, to manufacture it themselves. It appeared from the evidence that the respondents only produced in this way so much caustic soda as was required for the purpose of converting their naphthalene into beta-naphthol, and that they only used caustic soda produced by themselves for this purpose. Chlorine could be used for converting other residuals; but it did not appear upon the evidence that chlorine, which was a bye-product of the manufacture of caustic soda by the respondents, was used only for that purpose. It appeared that at all events some of the chlorine had been converted to another purpose, and was so used. The appellant was the Secretary of another Company which apparently dealt in caustic soda, but, being qualified for the purpose of bringing this action by the purchase of shares or stock in the respondent Company, he had taken the objection that the latter Company had no power under their Statutes to manufacture caustic soda, even for use in converting their naphthalene into beta-naphthol; and he had brought this action claiming an injunction to restrain them from making caustic soda. The action was dismissed by Mr. Justice Astbury, and the decision stood confirmed by the Court of Appeal. There was no dispute as to the legal propositions which were to be applied in this case. It was enough to refer to the rule as laid down by Lord Watson in the case of *Baroness Wenlock v. the River Dee Company*, when he had said: "Whenever a corporation is created by Act of Parliament, with reference to the purposes of the Act, and solely with a view to carrying those purposes into execution, I am of opinion not only that the objects which the corporation may legitimately pursue must be ascertained from the Act itself, but that the powers which the corporation may lawfully use in furtherance of those objects must either be expressly conferred or derived by reasonable implication from its provisions." To this statement, the Lord Chancellor added a sentence from the speech of Lord Selborne, in the case of the *Attorney-General v. the Great Eastern Railway Company*, in which he had said: "I agree with Lord Justice James that this doctrine of *ultra vires* ought to be reasonably, and not unreasonably, understood and applied, and that whatever may fairly be regarded as incidental to, or consequential upon, those things which the Legislature has authorized ought not (unless expressly prohibited) to be held, by judicial construction, to be *ultra vires*."

With these statements of law in mind, the Lord Chancellor turned to the Statutes of the Gas Light and Coke Company. The first material section was section 40 of the Company's Act of 1868 (part of which he read). Applying that section to the particular facts of this case, it appeared to him to result in this, that the Company might convert and deal with naphthalene. In other words, they might treat naphthalene by converting it into some other marketable product. It was plain that, for the purpose of so converting naphthalene in the best way, they must have caustic soda, and accordingly the provision of caustic soda was incidental to the conversion of naphthalene. The only point was whether this caustic soda must needs be provided by the method of purchase, or whether it was in the power of the Company as incidental to their powers to convert, themselves to manufacture caustic soda. If that section stood alone, it would appear to him to be reasonably plain, on the facts of the case, that the manufacture of caustic soda was incidental to the process of con-

version of naphthalene into beta-naphthol, or, in other words, that the manufacture of caustic soda was a part of the process of conversion.

But the Statutes did not stop there; and His Lordship went on to deal with section 43 of the same Act. He considered that the section, properly read, did authorize the Company to convert its naphthalene into beta-naphthol, and to provide the necessary materials for that purpose. Again, under that section, he saw no reason why the materials should not be provided by the process of manufacture, or why they should only be provided by the process of purchase.

After quoting the other relevant sections of the Company's Acts, His Lordship said that, if it could be suggested that the Company in this case were engaged in manufacturing caustic soda for the purpose of sale, the result might be very different; but he considered it was plain from the evidence that they were doing no such thing, and that they were making caustic soda only for the purpose of using it in the process of converting one of their residuals into a marketable product.

As regards chlorine, this appeared to be a small matter. Chlorine was not made for the sake of making chlorine; it was a necessary bye-product evolved in the process of making the caustic soda. Chlorine might be, and possibly would be, used for converting some residuals into something which could be sold, but, in any case, it must be got rid of by the Company; and he did not think the plaintiff had said, in his pleadings, that it was the fact that the Company, in that respect, were going beyond their powers.

In summing-up the case, His Lordship adopted the statement by Lord Justice Warrington in his judgment on the present case in the Court of Appeal, when he had said: "My view in reference to the facts of this case may be thus summed-up. The defendant Company have express powers to convert naphthalene into beta-naphthol; they have by reasonable implication a power to provide the proper reagent for that purpose—namely, caustic soda—a proper and reasonable means of providing that substance is to make it, and, to do so not being excluded, they have by reasonable implication the power to provide the substance by that means."

Therefore, the Lord Chancellor moved that the appeal be dismissed, with costs.

Lord Dunedin said he had not felt any doubt that the decision of the Court of Appeal was right. Their Lordships had been favoured with a very careful and minute analysis of the various Statutes which applied to the Company. Speaking for himself, he did not think the case was much helped by, or depended on, such analysis. He looked upon such Statutes as merely exegetical of the leading Statutes, and section 40 of the Act of 1868, in ordinary and non-technical language, seemed to him very clearly to authorize the Company to put the residual products into such a shape as to make them commercially valuable. Then they had to see whether what was done fell within the dictum of Lord Watson which had been quoted by the Lord Chancellor. The Company must have reagents for dealing with those residual products; and he could not see that there was really any difference between buying the reagents and providing them by manufacture in their own works. At the same time, if a case had been made out that, under cover of doing something incidental to the proper exploitation of waste products, the respondents were really entering the market as producers of some product not itself a residual product, and thereby really becoming manufacturers of some other articles than those which they were allowed to manufacture under their Statutes, they might, he considered, have been restrained. But no such case had been made; and he considered the appeal failed.

Lord Atkinson said he thought the judgment in the Court of Appeal was right, for the reasons given in the separate judgments there.

Lord Sumner and Lord Buckmaster concurred.

The appeal was formally dismissed, with costs.

APPLICATIONS FOR PATENTS.

[Extracted from the "Official Journal" for June 4.]

Nos. 13,541-14,233.

Cowan, Sir H.—"Safety devices for gas-heated apparatus." No. 14,016.

Drake, J. W.—"Valves for gas, &c., mains." No. 14,114.

Drake, J. W., and Drakes, Ltd.—"Apparatus for treating coke discharged from retorts, &c." No. 14,116.

Finlayson, T. C.—"Manufacture of gas." No. 13,767.

Harrisson, F. J.—See Drake, J. W. No. 14,114.

Johnson, C.—"Gas heating burners, &c." No. 13,562.

Kirkham, Hulett, & Chandler, Ltd.—"Apparatus for effecting intimate contact between liquids and gases." No. 13,657.

Parkinson Stove Company, Ltd.—See Cowan. No. 14,016.

Reber, J. W.—"Dry-quenching coke." No. 13,618.

Slater, W. F.—See Kirkham, Hulett, & Chandler, Ltd. No. 13,657.

Smith, E. W.—See Finlayson, T. C. No. 13,767.

Staniforth, H.—"Apparatus for controlling lighting, &c., of gas burners." No. 13,942.

Woodall-Duckham, Ltd.—"Dry-quenching coke." No. 13,618.

Woodall-Duckham, Ltd.—"Manufacture of gas." No. 13,767.

Mr. Arthur Sainsbury, Secretary to Messrs. Ewart & Son, Ltd., notifies shareholders that his Directors have declared a dividend for the half-year ending June 30, 1925, on the preference shares at the rate of 16 p.ct. per annum, and an interim dividend on the ordinary shares at the rate of 32 p.ct. per annum (or 16 p.ct. for the full year), both subject to income-tax. These dividends are at the same rate as those paid on June 30, 1924, in respect of the first six months of last year. Arrangements have been made with the Liquidator of Messrs. Ewart & Collis, Ltd., for the transfer before June 30 of the shares now held by him in Messrs. Ewart & Son to the shareholders in Messrs. Ewart & Collis, in order that they, as shareholders in Messrs. Ewart & Son, may receive the dividends on the preference and ordinary shares payable upon that date.

MISCELLANEOUS NEWS.

GAS REGULATION ACT APPLICATIONS.

The following notices have appeared in the "London Gazette" regarding applications to the Board of Trade under the Act.

SPECIAL ORDERS.

Chapel Whaley and District Gas Company.

The Company intend to apply for an Order under section 10, to enable them to use for gas-works purposes scheduled land, to raise additional capital, and to make provisions regulating the supply of gas.

Solihull Gas Company.

The Company notify their intention of applying to the Board of Trade for an Order under section 10 to enable them to acquire additional land, to raise additional capital, and for other purposes.

BIRMINGHAM GAS DEPARTMENT.

The Birmingham Gas Committee, in their report to the City Council, recommend that the prices of gas be increased as from the June readings of the meters, for lighting and domestic purposes, up to and including 100,000 c.ft., from 2s. 10d. per 1000 c.ft. to 3s. 2d. The percentage increase of the suggested price over Midsummer, 1915, is 58·33. Other prices are also raised.

The Committee, in an explanation for the increase, point out that in June last year they commented on the reductions in price which had been made during the preceding twelve months, and drew attention to the fact that residual products were then showing signs of weakening, and that there had been a considerable fall in the value of tar products. This made the position one of much anxiety, as there was very little margin in the existing scale of charges. Unfortunately there had been a continued slump in residual products, which had so adversely affected the finances of the Department as to make it necessary to increase the price of gas. The fall in the revenue from tar during the year was nearly £70,000, notwithstanding that a larger quantity was produced in the year ended March, 1925; and it was interesting to note that, if values had been maintained at the level of the previous year, additional revenue to the extent of £94,757 would have been provided. After taking into account the increased quantity of ammoniacal liquor made and sold during the year, the fall in value of this residual has resulted in a loss of revenue equal to £21,644. A reduction of 5s. per ton had to be made recently in the price of coke, owing to the increasing stocks and the general reductions in price made by other gas undertakings, which made it very difficult to obtain sufficient orders to keep the yards clear of this product. That reduction represented a loss of income of £100,000 per annum. An amount of £60,000 should have been allocated to Nechells Works reconstruction in accordance with the arrangement made with the Finance Committee; but, owing to financial stringency, this could not be done. Provision must, however, be made for resumption of the annual payment in the current year.

As to the annual accounts, the Committee state that they show a deficiency of £78,518, which amount has been transferred from the reserve fund. The expenditure for the year amounted to £2,226,764, a decrease of £117,023, but credit had been taken for an abatement of income-tax on replacement of plant amounting to £63,555. That item would not recur in future years.

The Unemployment Relief Schemes which have been adopted by the Council had involved the Committee in heavy expenditure in altering the position of, and rearranging, gas mains in the thoroughfares which had been improved and reconstructed. The expenditure under this head amounted to £58,733. During the year, 810,110 tons of coal were carbonized—an increase of 10,951 tons over the previous year. In addition 1,734,723 gallons of oil were used in making carburetted water gas. The gas sold amounted to 12,659 million c.ft., the largest quantity sold in any year in the history of the undertaking, and an increase of 5·35 p.ct. over the quantity sold in the preceding year. The increase was no less than 642¼ million c.ft.; and of this quantity approximately 358¼ millions were due to increased demands for lighting and domestic purposes. The average net price realized per 1000 c.ft. during the year was 2s. 5·47d., as against 2s. 9·77d. in the year ended March, 1924.

The two concrete gasholder tanks at the Washwood Heath Works had been satisfactorily completed, and considerable progress had been made with the erection of the holders and framework. One holder would be completed in August next, and the other towards the end of the year. It had become necessary to carry out extensive repairs to 22 beds of vertical retorts at the Windsor Street Works, which had been in operation continuously for five years. The repairs would be carried out during the coming summer when the plant could be let down without inconvenience, owing to the smaller demand for gas. The cost would be approximately £38,000.

Extensions of Gas Mains at Stafford.—At a recent meeting of the Stafford Town Council, the Gas Committee recommended that a 12-in. main be laid along the Wolverhampton Road from Park House to the junction of Burton Lane, a distance of 403 yards, and a 10-in. main along Burton Lane for a distance of 416 yards, at an estimated cost of £1800. The recommendation was carried.

Progress at Ashbourne.—At the monthly meeting of the Urban Council, a report on the gas undertaking for the year ended March 31 last was received, showing a gross profit of £3613. After meeting loan charges, &c., a net profit of £94 remained. The make of gas had increased by 2,572,700 c.ft. to 49,000,000 c.ft. for the year. In view of the anticipated saving in the cost of coal during the current year, it was decided to reduce the price of gas by increasing the discounts to ordinary consumers, but the exact amount of discount could not be fixed until the coal contracts were settled.

SOUTHAMPTON GAS ORDER.

Mr. H. C. HONEY (Director of Gas Administration at the Board of Trade) inquired into an application by the Southampton Gaslight and Coke Company for a Special Order under section 10 of the Gas Regulation Act, on Monday, June 8, at the offices of the Board. The purposes of the Order are to extend the area of supply of the Gas Company and to authorize new provisions with regard to capital and borrowing powers. There are also a number of miscellaneous provisions. The new area which is to be added to the Gas Company's existing area of supply consists of the parishes of Dibden, Marshwood, and Fawley, and the parishes of Bursledon, Botley, and Hedge End. With regard to dividends, a clause in the Order provides that the limitation of dividends to 5 p.ct. per annum on the ordinary capital and 4 p.ct. per annum on the preference capital, which was imposed on capital issued under the Company's Act of 1906, is not to apply to the capital issued after the date of the Order, but the Company are not to pay a dividend larger than 6 p.ct. on such capital, unless a larger dividend is necessary on the ordinary capital to make up the deficiency of any previous dividend. The Company, however, are not to make up a deficiency in any previous dividend after five years from the date when such previous dividend was paid or payable. Borrowing powers are sought by the Company up to one-half of the amount of the paid-up capital. Powers are also sought to issue debenture stock; and the interest on that debenture stock, or on any money borrowed under this Order, is not to be more than 6 p.ct. Powers are also contained in the Order to grant pensions and to adopt a co-partnership scheme.

Originally there were three sets of objections to the provisions of the Order. The first was by the Bursledon Bridge and Roads Company, who asked for protection in respect of the laying of gas mains over Bursledon Bridge and along roads which are owned and maintained by the Bridge Company. The opposition was withdrawn, however, on the insertion of an agreed clause. Another set of objections was raised by the Southampton Corporation; but certain amendments to the Order were agreed between the Gas Company and the Corporation. The third series of objections came from the Southern Railway Company, who asked for protective provisions.

The Railway Company were represented by Mr. W. BISHOP (Solicitor to the Railway Company); and Mr. C. F. BAKER (Messrs. Bircham & Co., Parliamentary Agents) represented the Gas Company.

Mr. BAKER, dealing with the Railway Company's objections, said that one of these related to a clause giving the Gas Company power to lay pipes for ancillary purposes, but a proviso had been added to the effect that the Company were not to lay such mains under any railway of the Southern Railway Company without their consent. The proviso also states that such mains may only be laid in certain specified streets in the borough of Southampton, and then only with the consent of the Corporation.

Another objection by the Railway Company which was disposed of by agreement had reference to the clause relieving the Gas Company of the obligation to supply gas for other than lighting and domestic purposes from mains of insufficient capacity. The Company deleted the clause in the original Order, and inserted in its place the clause recently agreed between the National Gas Council and the Railway Companies, and which has come to be known as the "Pinner" clause. [This clause was inserted recently in the Mansfield Corporation Bill, and is set out in the "JOURNAL" for June 3, p. 677.]

The outstanding objections of the Southern Railway Company arose in connection with a clause which they asked should be inserted in order to protect their interests. Mr. Baker said that the Gas Company were prepared to give a certain measure of protection, and that would be agreed. The Railway Company contended that the provisions of the Gas Works (Clauses) Act, 1847, did not afford adequate protection for their roads, bridges, level crossings, and other works, and asked for special protection. The Gas Company, on the other hand, disagreed that the Act of 1847 did not afford adequate protection, and pointed out that the Gas Works (Clauses) Acts of 1847 and 1871, which were incorporated in their Acts and the present Order, had afforded adequate protection to the Railway Company in the past. If any alteration of the general law were necessary, it should be made by public legislation, and they objected to being placed in a position different from that of other gas undertakings, as the result of the insertion of special provisions in the present Order.

Mr. BISHOP said that the Railway Company were now asking for no more than they had been granted on many occasions. The clause which he now asked should be inserted in the present Order had been amended, and agreement had been reached between the parties, except in respect of two sub-clauses. The first of these related to the carrying of mains under railways by the Gas Company, and provided that the Gas Company should restore and make good, to the reasonable satisfaction of the Railway Company's engineer, the railways which might be disturbed or interfered with. The discussion arose on a proviso which it was proposed should be added, to the effect that, if the Engineer of the Railway Company should think it necessary in any case for the works of the Gas Company (other than the actual laying down of mains or pipes) to be executed or carried out by the Railway Company, such works might be carried out by the Railway Company, and the reasonable expense incurred by them should be repaid to them by the Gas Company.

It was pointed out by Mr. Bishop that the present case, so far as the Railway Company were concerned, was exceptional. A new railway was being built, the greater part of which was included within the proposed extended area of supply of the Gas Company. This line had been difficult to construct, owing to the nature of the subsoil and the waterlogged condition of the country. The Railway Company's Engineer feared that the maintenance of this line would be difficult for some time to come, and was afraid that work might be carried out by the Gas Company which would seriously jeopardize the Railway Company, and which might lead to the suspension of traffic. He wished to guard against this.

Mr. BAKER remarked that the Gas Company were anxious to do all they could to avoid difficulty.

Mr. *A. W. Szlumper* (Chief Engineer to the Railway Company), in evidence, referred to a case in which works carried out by a county council had resulted in damage to the railway, which had had to be repaired at considerable expense. If the proviso asked for by his Company were inserted in the present Order, the Gas Company would not be put to any expense; on the contrary, the probability was that the Gas Company would be saved expense. After many years' experience, he had come to the conclusion that some such definite protection was needed by railway companies.

Mr. BAKER, in the course of discussion, said that if it were made clear that the works which the Railway Company were allowed to carry out were limited to supporting and protecting their railways, he did not think the Gas Company would object. The proviso in its present form would leave the Railway Company power to fill in a trench after a gas main was laid; but, if it were not filled in properly and the gas main fractured as a result, who would be responsible?

Further discussion then ensued in order to arrive at a suitable wording of the proviso in question, and finally Mr. Honey suggested that the parties should consult privately. His suggestion was adopted; and it was subsequently agreed that the Railway Company should have power, if their engineer thought necessary, to carry out the works of the Gas Company—other than the actual laying down of mains or pipes, "including the filling in and consolidating of the trench in which such mains or pipes are laid."

The other proposed sub-clause to which the Gas Company objected was one providing that, if any injury or damage to or interruption of traffic on the railways of the Railway Company arose in any way owing to the construction, existence, or failure of the works of the Gas Company, they should make full compensation to the Railway Company.

In the course of the discussion upon this, Mr. Bishop said he did not quite appreciate the Gas Company's reasons for objecting, because it was a provision which the railway companies had invariably obtained in the past.

Mr. HONEY asked to what extent this sub-clause was an extension of the general law.

Mr. BAKER said that at present the Gas Company were only liable in the case of damage caused through their negligence.

Further discussion of the matter ensued, and various forms of wording were considered. Finally, the Gas Company agreed to the insertion of the sub-clause, with the deletion of the word "existence." Thus, they are to be liable to make compensation to the Railway Company for injury or damage to or interruption of traffic arising owing to the "construction or failure" of the works of the Gas Company. Mr. Honey intimated that the Board of Trade would insert the sub-clause in this form.

This disposed of the opposition of the Railway Company.

Consideration was then given to a request by the Southampton Corporation that the charge for gas within the Borough should always be 2_2d. below the price charged outside. Mr. Baker said that the Gas Company were prepared to put in a provision to the effect that the charge within the Borough should always be less by 2 d. per therm than the highest price charged outside the Borough; but they could not possibly agree to a provision which might have the effect of making them charge considerably less than the amount they ought to charge in Southampton. On the outside fringe of the Borough they would not charge the maximum, but the lowest price they could charge, and it would not be fair to make the Company reduce the charge in the Borough accordingly. On the outside limits of supply, the Company were charging the full differential, whereas on the fringe of the Borough they were not.

Mr. HONEY said that the Southampton Gas Company's Act of 1898 contained a proviso that, if the prices were increased, the increase should be made uniformly over the whole of the limits. There was no provision, however, that reductions should be uniform. In effect, therefore, the Corporation were asking that if there were a difference at present between the prices in the Borough and the outside areas, that difference should be stereotyped for a time. He asked how the figure of $2\frac{3}{4}$d. was arrived at.

Mr. *J. R. H. Jacobs* (General Manager to the Company) said that was the figure given in the Company's Charges Order of 1921, where it was laid down that the maximum prices should be $16\frac{3}{4}$d. and $18\frac{1}{2}$d., in place of the maximum prices given in the Act of 1898—namely, 3s. 6d. and 4s. 6d. per 1000 c.ft.

Mr. HONEY said there was no differential mentioned in the 1898 Act, but two maximum prices, which could be dealt with independently so far as a reduction was concerned, but which must be dealt with alike so far as an increase was concerned.

Mr. *Jacobs* agreed.

Mr. HONEY said that, having regard to the practice of the Company in the past with regard to these differential prices, and to the fact that in 1898, when the maximum price in the outside districts was fixed, there was no provision that the Company were for a time to charge a higher price in the outside district than in the inner district, he was not disposed to recommend the Board of Trade to insert anything in the present Order. It seemed to him that what the Corporation were now asking the Board of Trade to do was not merely to affect the price in the new area, but to affect the price in all the districts now supplied by the Company outside the Borough, which latter were dealt with by the Act of 1898. Certainly, without hearing representatives of the outside districts, he would hesitate to put the Company under an obligation to charge a higher price in those districts for a time than was charged within the Borough. He considered that an important change of this kind ought not to be made without giving the people affected an opportunity of being heard.

Another matter discussed was a clause in the present Order giving the Company power to levy such charges as they thought fit for taking the reading of any meter fixed in a house, which was either in whole or in part let furnished at times other than those of the Company's

periodical readings. There was a proviso to this clause, to the effect that for each reading taken within the Borough as constituted at the date of the Order such charge should not exceed 1s. Mr. Honey asked why the maximum charge of 1s. should be confined to within the Borough. The reply was that this was due to the special circumstances of the Company. The area covered was a large one, and the offices were situated in Southampton. The fee should be kept as low as possible within the Borough, but it was considered reasonable that it should be higher at the extreme limits of the area. The probability was that in the immediate neighbourhood of the offices of the Company the charge would be less than 1s., and perhaps nothing at all. On the other hand, if a special reading were made on the extreme edge of the area, a man would have to travel about 14 miles each way for the purpose. Often the Company received notice at the last minute that a house was changing hands, and the outgoing tenants wanted the meter read and the account left the same day. This meant sending a man specially from the office to read the meter and collect the money.

Mr. HONEY intimated that the clause could be inserted as put forward.

The inquiry then closed.

SAFEGUARDING OF INDUSTRIES ACT.

Gas Mantle Inquiry.

(*Continued from p.* 749.)

Tuesday, June 9.

The Committee concluded their proceedings on Tuesday, June 9.

Herr *Heinrich Zeigler* re-entered the witness chair, and handed to the Committee copies of wages agreements into which his Company had entered recently. These had been asked for previously by the Chairman. A statement as to the taxes payable in Germany was also produced.

Witness was then cross-examined by Mr. Soper (for the applicants), whose object was to show that Herr Zeigler's Company was an amalgamation of a number of foreign mantle manufacturing concerns, and to emphasize that the opposition to the present application was in effect the opposition of foreign manufacturers, and was not representative of the general body of importers in this country. His questions were shortened, however, by an intimation from the Chairman (Sir Frederick Mills) that this was quite clear.

Witness made a correction to his previous evidence with regard to the cost of carriage, freight, and insurance from the German factory to the port of discharge in the United Kingdom. This he had said was 3s. per gross; the wholesale price in Germany was 3s. below the wholesale price here, so that he was sacrificing nothing by exporting to this country. He now said, however, that the cost of carriage, freight, and insurance was 2s.

With regard to prices in this country, witness agreed that during 1923 (when there was a duty on German mantles under Part II. of the old Safeguarding of Industries Act), his prices here were less than the prices operating at the present time. He admitted that those 1923 prices were based upon those ruling in this country, and not upon his production costs, the reason being that, owing to the inflation of German currency, he did not know what his production costs were. At present, however, prices were based on production costs, which he could ascertain because the German currency was stabilized. The stabilization took place about November, 1923; and although the low prices charged yielded his Company a profit before that time, they did not yield a profit after stabilization.

Asked what was the present price of standard German mantles in the United States, witness said he did not now export to that country, because the duty was too high.

This concluded the evidence on behalf of the importers who are opposing the application, and further evidence was called on behalf of the applicants.

Mr. *N. W. Buis* (who gave evidence on a previous occasion as to the rates of wages paid by mantle manufacturers in Poland) said he had been to Germany within the last fortnight, and had ascertained from a worker at the Auer Company's factory at Berlin the rates of wages paid there. These were considerably below the figures given by Herr Zeigler. He had also advertised for clerical workers, and the salaries asked for by those who had replied to his advertisement were also low.

Cross-examined by Mr. Macaskie (representing the importers) witness said that before leaving for Germany he had seen the figures which were to be given on behalf of the importers as representing the rates of wages paid by the Auer Company at Berlin. He had not tested these by putting them to his informant.

Mr. *C. S. Garland* (Managing Director of the Clay Ring Company, Ltd.) said that prior to the war the manufacture of clay rings in this country was in German hands, and he believed the business was in close association with the German gas mantle industry. In the early part of the war the factory (which was situated at Earlsfield, London) was taken over by the Custodian of Enemy Properties, and in 1917 the shares were sold under the Trading with the Enemy Act. Several British mantle manufacturers, feeling that it was necessary to remove this important source of raw material from any possibility of foreign control, had combined to purchase the shares of the business. The output of the factory had proved to be insufficient for the demand in 1917 and 1918, and two other factories were purchased—one at Nottingham, and the other at Ashby-de-la-Zouch, in Leicestershire. In 1920 all three factories were working, and the output of rings was over 60,000,000, the number of people employed being 520. The renewed importation of German mantles, however, had necessitated the closing of the two new factories, and the concentration of manufacture at Earlsfield, for the sake of economy. At the end of 1924 the workers employed there numbered 172. With the increased importation of German, Austrian, Italian, and Polish mantles in 1925, the output at the factory had been further reduced, and only 102 workers were now employed. There were only four manufacturers of these rings in the world, only one being in England. It was of the utmost importance to the British mantle manufacturers that the Earlsfield factory should be kept in operation, and that it should have a sufficient output to ensure its being able to compete on reasonable terms with the factories abroad. If output were reduced so that the Clay Ring Company could only sell at its present price at a loss, the British mantle manufacturers would either have to bear those losses, which would make them still less able to meet competition, or close the ring factory. In the latter case they would be entirely at the mercy of their German competitors for supplies of one of their essential raw materials, and one which, probably as much as thorium nitrate, was now a key to the mantle situation.

In February of this year, Mr. Garland had made inquiries as to the rates of wages paid in German mantle factories, and had obtained from three different sources figures which were substantially identical to those given by Mr. Talbot as the rates obtaining in Germany at that time. As to the reduction in the number of mantles consumed in this country now as compared with the period before the war, he attributed this to the change from the upright to the inverted type of mantle, and even more to the great improvement in quality of the inverted type.

Cross-examined, witness said that the price of mantle rings was not fixed by the mantle manufacturers; he fixed the price in relation to the cost of production.

Mr. *Edmund White* (Managing Director of Messrs. Hopkin & Williams (Travancore), Ltd., and of Messrs. Thorium, Ltd.) referred to the German control of the deposits of monazite sand (from which thorium nitrate was made) before the war, and said that when war broke out, thorium nitrate was not being commercially manufactured from monazite in this country. As soon as supplies were available, however, Messrs. Thorium, Ltd., commenced to produce thorium nitrate and cerium from monazite on a commercial basis. The manufacture of thorium in this country could not be safeguarded if gas mantles, which were virtually the only articles for which it was used, were allowed to come into this country with a duty calculated only upon the value of the thorium *qua* thorium contents of the mantle, and not upon the thorium in the form of gas mantles (including the cost of putting it in that form), or unless an effective duty were imposed upon the gas mantle itself. His was the only Company at present manufacturing thorium nitrate in this country. If demands for thorium nitrate from British gas mantle manufacturers were further curtailed by reason of foreign mantle competition, then either the price would have to be increased or the manufacture of thorium nitrate, and with it cerium and mesothorium, would cease, and again the country would have to look to foreign countries in times of peace and war for those essential materials the manufacture of which had been considered by all Governments as a key industry.

In cross-examination, witness said that 50 p.ct. of the capital of Thorium, Ltd., was owned by a gas mantle manufacturing company, and the remainder by other interests; but the price of thorium nitrate was not controlled by mantle manufacturers.

This concluded the evidence for the applicants.

Herr *Zeigler* was then re-called for cross-examination by Mr. Soper with regard to the rates of wages paid by his Company. Witness said that the rates paid to the mantle operatives were the same as those paid in the Company's chemical factory, but those rates were not paid in an electrical factory also owned by them. Witness could not say whether or not Mr. Soper was correct in suggesting that the wages paid in other mantle factories in Germany were only two-thirds of those paid by Herr Zeigler's company, or that the latter were the highest paid in any industry in Germany.

Mr. MACASKIE, summing up on behalf of the opponents, contended that the whole of the conditions laid down by the Board of Trade had to be satisfied by the applicants if they were to be successful, but that in only one particular had the applicants been able to satisfy those conditions. The industry was not of substantial importance from the point of view of the number of workers employed, or from the national point of view. In his comments in this connection, he said that from the standpoint of volume of employment the industry was miserably out of the picture. The real difficulty of the industry before the war, when there was a greater degree of competition than now, was not that the British industry could not cope with the demand, but that the supplies of monazite sand, from which thorium nitrate was obtained, were under foreign control. This did not apply now, however, and there was no reason to suppose that the industry would ever again be short of essential supplies. As to the suggestion that German mantles were being retained for consumption in this country in abnormal quantities, he met that by pointing out that before the war foreign manufacturers supplied 75 p.ct. of the home consumption of standard mantles, whereas in 1924 they had supplied only 36 p.ct. Also, 1920 should not be taken as a standard year in this connection, because foreign manufacturers had not had time to re-organize their competition then. In connection with this competition, Germany had not been breaking new ground, but was simply returning to a market which it had held up to 75 p.ct. of the consumption before the war. Commenting on the allegation that foreign mantles were being sold in this country at prices below which they could be profitably manufactured here, he said that, although costs of materials were about the same in this country and in Germany, and there was only a difference of 1d. per hour between the wages paid in the two countries, there was still an alarming difference in costs of production, and his suggested explanation was that the overhead charges of British manufacturers were too high. Overhead charges, however, did not enter into the inquiry, according to the Board of Trade instructions. Competition was not unfair, because conditions of employment in Germany were not inferior to those in this country, except to the extent of 1d. per hour in wages; but against this advantage, German manufacturers

had to meet freight and insurance charges when exporting to this country. Again, to show that competition did not seriously affect employment here, he pointed to the small number employed in the British industry.

MR. SOPER, in his final remarks, stressed the national importance of the industry, for the reasons already given in his evidence. Gas was probably the predominant source of artificial lighting in this country; and the gas mantle was the key to modern gas lighting. It had enabled great economies to be effected in gas manufacture, because the use of the mantle had permitted valuable bye-products to be stripped from gas. He also laid emphasis upon the value of the gas mantle from the point of view of the conservation of the nation's coal resources. Mr. Soper examined the conditions laid down by the Board of Trade for the guidance of Committees, and, in claiming that these conditions had been fulfilled, added that a *prima facie* case had to be made out for a protective duty before the Board of Trade would appoint a Committee to inquire into it. The Board must have been satisfied that a *prima facie* case had been made out, or the present inquiry would not have been held. The year which he asked should be taken as a standard in arriving at a conclusion as to whether foreign gas mantles were being retained for consumption in this country in abnormal quantities was 1920, because that was the last year in which the industry was in a position to work economically and to sell at a reasonable profit. The balance-sheets of the companies concerned had shown that those companies had not paid a dividend since 1920. With regard to wages in Germany, he pointed out that when the British manufacturers had applied for a duty on German mantles under Part II. of the old Safeguarding of Industries Act, and when German witnesses came here to give evidence against the application, wages in Germany had shown an extraordinary rise. The same thing had happened in the present case. Less than three weeks ago there was again a rise in wages in one of the factories in Germany, which was due to Herr Zeigler's company having made themselves a party to an agreement to pay wages which were being paid in the chemical industry. Mr. Soper suggested that, in view of Herr Zeigler's admission that the retention of his share in the British market was a matter of vital importance to his Company, it might be a prudent action to agree to pay high wages, if, by doing so, the present application could be defeated. In his further remarks, Mr. Soper refuted the suggestion that overhead charges in this country were too high, and said his figures showed that efficiency in this country was higher than in Germany. Finally, he asked the Committee to recommend the imposition of a flat rate duty on imported mantles rather than an *ad valorem* duty, and said that he was satisfied that his suggested figure of 10s. per gross was not a penny too high; in fact, some of his colleagues considered it too low.

At the conclusion of the proceedings, the Chairman thanked the leaders and witnesses on both sides for the courteous manner in which they had put their cases and given evidence, and intimated that the Committee would consider its opinion at an early date.

The Committee's decision will be published in due course.

NORTH-EAST COAST COAL TRADE.

From our Own Correspondent.

The gloomy market conditions continue unchanged, and there is nothing new to report. The policy of working short time rather than accepting business at still lower prices is becoming more and more necessary, as buyers' ideas seem to be that every order should be taken at a little less than the one before, irrespective of what the loss to the producers may be. More and more collieries are realizing the need for making a stand, but the decreased quantities available for sale still seem to be far more than enough to meet the demand.

It does not seem likely that there can be any change in the position while the present uncertainty prevails as to the future. Both buyers and sellers are disinclined to commit themselves until it can be seen what arrangement is likely to be arrived at with regard to wages.

In gas makes, Wear Specials continue to quote 18s. 6d. to 18s. 9d. f.o.b., and best qualities 18s. to 18s. 3d. These prices are nominal, and actual business is subject to negotiation. Seconds and others are 15s. 9d. to 16s. 3d. There is practically no demand for coking sorts, and 16s. to 16s. 3d. is the price of best makes.

YORKSHIRE AND LANCASHIRE COAL TRADE.

From our Local Correspondent.

The condition of affairs in the coal trade in Yorkshire and Lancashire is gradually, but surely, assuming a very grave aspect. Many of the larger collieries are threatened with the immediate prospect of having a struggle to work even three days a week. The fate of the smaller pits with lower outputs and the increased cost of production is causing the greatest anxiety to those concerned.

House coal, which during normal times flows into the shipment areas, is held up on account of the higher rates of exchange and the keen competition from the nearer Continental producing centres; while the home market demands are, owing to climatic conditions, reduced to a minimum. The present indications of still further reduced prices even of the best industrial fuels are likely, however, to have some effect on the improvement from the larger manufacturing centres; and with coal and furnace coke reduced to present-day figures, there is some hope for the iron and steel trades.

Gas coal prices still vary, with indications that consumers are inclined more than ever to buy washed nuts and to leave screened and unscreened gas coal alone. Some collieries now stipulate that any expected offers should be in proportion for washed nuts and screened coal.

The unsettled state of the market rather inclines to the opinion that rock bottom has not been touched in respect to the figures likely to obtain for the remaining purchases of gas coal. Some of the contracts fixed months ahead of the earliest deliveries will be slightly above the average price.

There is no change in the shipping outlook, though prices have come to such a low level, showing a big loss to collieries, that it is apparent that the rates of exchange will have to operate much differently before business of any magnitude is possible.

COAL TRADE IN THE MIDLANDS.

From our Local Correspondent.

Drastic steps are being taken to bring the output of coal into correspondence with the shrinkage of demand. It is significant of the condition of stocks and the view taken as to the issue of the negotiations on which the working of the industry after this month so largely depends that collieries are reducing current production decisively. They can hardly do otherwise, for coal cannot be raised at anything like the prices at which some of the stocks are being liquidated. Most of the big gas undertakings have now completed contracts for the new trading year. Commitments are on a much smaller scale than twelve months ago. Apart from undelivered balances on the old contracts, industrial conditions do not dictate such a cautious policy as big consumers thought necessary when the perils of the railway strike were fresher in their memory. A number of municipally owned undertakings cannot square their accounts owing to the slump in residuals, and increased prices will have to be charged. At Birmingham the fall in the revenue from tar was nearly £70,000, in spite of increased production, and there was a drop of £21,044 on ammoniacal liquor. A reduction of 5s. has been made recently in the price of coke, representing a loss of income of £100,000 per annum. It is proposed to make increases in the scale of prices for gas varying from 3d. to 4d. per 1000 c.ft. forthwith.

CURRENT SALES OF GAS PRODUCTS.

The London Market for Tar, Tar Products, and Sulphate.

LONDON, *June* 15.

There are no particular changes to report in the London tar products market. There is a moderate amount of inquiry for pitch for next season's shipment, but buyers' ideas are below those of sellers.

There is a fair demand for creosote, but supplies are scarce for the next few months.

The demand for road tar is taking up current makes of both pitch and creosote.

Solvent naphtha is in request, and available supplies are readily absorbed. This is also the case with benzole and toluole.

Current values are as follows: Pitch, 41s. to 42s. per ton, nominal; creosote, 7d. per gallon in bulk at works; solvent naphtha, 1s. 8d. to 1s. 9d. per gallon 95/160 quality; pure benzole and pure toluole, 1s. 11d. to 2s. per gallon.

Tar Products in the Provinces.

June 15.

There is little alteration in the markets for tar products.

For pitch there has been a little more inquiry during the past week, and it is evident that some consumers would like to purchase for next season's delivery.

In creosote there has been a little inquiry, but no alteration in the price.

Benzole and solvent naphtha are in fair demand.

Crude carbolic and crystals are still neglected.

The average values for gas-works products during last week were: Gas-works coal-tar, 26s. to 31s. Pitch, East Coast, 39s. to 40s. f.o.b. West Coast—Manchester, 34s. to 35s.; Liverpool, 35s. to 36s.; Clyde, 38s. to 39s.; Benzole, 90 p.ct., North, 1s. 7½d. to 1s. 8½d.; crude, 65 p.ct. at 110° C., 1s. to 1s. 1d., naked at makers' works; 50-90 p.ct., naked, North, 1s. 7½d. to 1s. 8½d. Toluole, naked, North, 1s. 6½d. to 1s. 7½d. nominal. Coal-tar crude naphtha, in bulk, North, 7½d. to 8½d. Solvent naphtha, naked, North, 1s. 5d. to 1s. 6d. Heavy naphtha, North, 1s. to 1s. 2d. Creosote, in bulk, North, liquid, 5¾d. to 6d.; salty, 5½d. to 5¾d.; Scotland, 5½d. to 5¾d. Heavy oils, in bulk, North, 6½d. to 7d. Carbolic acid, 1s. 5d. to 1s. 6d. prompt. Naphthalene, £11 to £14; salts, £4 to £5, bags included. Anthracene, "A" quality, 2½d. per minimum 40 p.ct., purely nominal; "B" unsaleable.

CONTRACTS OPEN.

Coal.

The Bakewell Urban District Council are inviting tenders for the supply of 2500 tons of gas coal. [See advert. on p. 974.]

Tenders are invited by the Gas Committee of the Carnarvon Corporation for the supply of about 3000 tons of gas coal. [See advert. on p. 974.]

Tar.

The Edinburgh Corporation Gas Department are inviting tenders for the purchase of their coal gas and carburetted water gas tar. [See advert. on p. 974.]

An order for the repair and modernization of the purifiers at the Fleetwood Gas-Works has been placed by the Directors with Messrs. R. & J. Dempster, of Manchester. This will assist in relieving unemployment.

STOCK MARKET REPORT.

ARISING out of the failure of the recent capital issues, it is reported that further Colonial Government issues are banned for the present. The demand for fresh industrial capital is, however, increasing, and proposals involving a total issue of nearly £14,000,000 may be expected shortly. The principal of these are: Dunlop Rubber Company, Ltd., £5,000,000 5½ p.ct. Debenture at 97½ p.ct.; Union Cold Storage Company, Ltd., £3,200,000 6 p.ct. Cumulative Preference Shares of £1 at par; and Synthetic Ammonia and Nitrate, Ltd., £2,000,000 Debentures. Some of the issues are to provide for further extension of trade, which is hopeful; but the last of the three issues mentioned will not, we imagine, appeal to investors in gas companies, as it appears to be a direct challenge to the sales of sulphate of ammonia.

During the past week there were frequent bouts of heavy selling of gilt-edged stocks by underwriters with commitments on the recent issues, and prices were mostly weaker. Railways continued to be depressed; the hopes of improved traffic receipts over the holidays not being realized. Industrials were good in parts. The heavy over-subscription of the Allied Northern Newspaper Debentures attracted attention to other similar issues. Tobaccos and Silks were, as usual, prominent. Rubbers were very active; and if the price of the commodity is any indication of prosperity, there should be some good results announced later. Oils are rather a mystery. A reduction in price in gas oil last week is followed by an announcement of an increase in crude oil on the other side of the water. The fact remains that the leading shares showed improvements on the week.

Gas stocks and shares were in demand. Although most of the changes in quotations were due to interest or dividend payments, there were a number of other variations. Plymouth and Stonehouse moved up 1 point, and Hongkong and China 1½ points. The falls, however, still predominate; Liverpool 5 p.ct. ordinary, South Suburban ordinary, and Tottenham "B" with a drop of 1 point each, and Imperial Continental a drop of 2 points, were the sufferers.

The following transactions were recorded during the week: On Monday, Brighton and Hove original 167, 169, Cape Town 7¼ *ex* div., Continental Union 7 p.ct. preference 90½, European 7, Gas Light and Coke 83¼, 83½, 83⅝, 84, 84¼, Imperial Continental 147, 147½ *ex* div., Montevideo 67½, Primitiva 9s. 7½d., 9s. 9d., 10s., 4 p.ct. debenture (1911) 65, 66, South Metropolitan 93½, 93⅝, 94, 94¼, 94½, Tottenham 5½ p.ct. preference 104½. Supplementary prices, Swindon 5 p.ct., 70, 70½.

On Tuesday, Bombay 4⅞, Cape Town 7, 7⅛ *ex* div., Commercial 4 p.ct. 86, Gas Light and Coke 83½, 83½, 84, 84¼, 4 p.ct. preference 79⅞, Imperial Continental 146, 146½, 147, 149, 3½ p.ct. debenture 72½, 73, Liverpool 7 p.ct. preference 104⅝, Primitiva 9s. 9d., 10s., 4 p.ct. debenture (1911) 65½, South Metropolitan 93¼, 93½, 93⅝, 93⅞, 6½ p.ct. debenture 103¼, 103⅜, Tottenham 5½ p.ct. preference 104, 104½, 104¾. Supplementary prices, Sunderland 6 p.ct. maximum 102¼, 102¾, Worthing Coke consolidated 93, 93½.

On Wednesday, European 6⅝, 7, Gas Light and Coke 83½, 83¾, 84, 3½ p.ct. maximum 62, 4 p.ct. preference 79, 79¼, 3 p.ct. debenture 60⅜, Imperial Continental 146, 147 *ex* div., Primitiva 9s. 6d., 9s. 7½d., 9s. 9d., South Metropolitan 93½, 3 p.ct. debenture 60½, South Suburban 5 p.ct. 95, Tottenham 4 p.ct. debenture 77.

On Thursday, Bombay 5⅛, Brentford 4 p.ct. debenture 79 *ex* div., British 7 p.ct. preference 124, 124½, Cape Town 4½ p.ct. 1st mortgage debenture 73½, 74, European 7⅞, Gas Light and Coke 83½, 83⅝, 84, 4 p.ct. preference 79, 79½, 3 p.ct. debenture 59½ *ex* div., Hastings and St. Leonards 3½ p.ct. converted 76½, Imperial Continental 146, 147, Oriental 104½, Primitiva 9s. 3d., 9s. 6d., South Metropolitan 93½, 93⅞, South Suburban 5 p.ct. 94¼, Southampton 5 p.ct. maximum 81½, 82, Tottenham 4 p.ct. debenture 77, 77½, 78, 78½, Wandsworth "B" 111. Supplementary prices, Hartlepool 5 p.ct. maximum 91, St. Albans consolidated 101, 101½.

Brighton and Hove 168½, "A" 124½, Croydon 100, European 7, 7½, Gas Light and Coke 83½, 84, 4 p.ct. preference 79½, 79⅝, Imperial Continental 146, 147½, Primitiva 9s., South Metropolitan 93½, 93½, 94, 94¼, 6½ p.ct. debenture 103½, Tottenham 5½ p.ct. preference 104½, 104½, Wandsworth "A" 130, "B" 110½. Supplementary prices, Shanklin 5 p.ct. consolidated 100, 100½, Walton-on-Thames and Weybridge 7 p.ct. "B" 10½.

At the close of the week monetary conditions in Lombard Street were easier. Renewals of day-to-day advances were arranged on the lower basis of 3½ p.ct. Business in the discount market was on the small scale; and although the Treasury Bill rate was slightly higher—£4 7s. 10·41d. p.ct.—there was little effect on the open market quotations.

On the Foreign Exchange Market both francs and lire were offered freely, and the rates of these exchanges depreciated further. French francs closed at 100.22½, Belgian francs at 102.10, and Italian lire at 122.95. Sterling on New York was quiet, and the rate closed slightly lower at 4.85 $\frac{27}{32}$.

Silver closed at 31$\frac{3}{16}$d. per oz., and gold was unaltered at 84s. 11½d.

The Bank Rate is 5 p.ct., to which it was raised from 4 p.ct. on March 5. Bankers' deposit rates are 3 p.ct. The deposit rates of the discount houses are 3 p.ct. at call and 3¼ p.ct. at notice.

Issue.	Share.	When ex-Dividend.	Dividends. Prev. Hf.Yr.	Dividends. Last Hf. Yr.	NAME.	Quotations. June 12.	Rise + or Fall − on Week.	Transactions Lowest and Highest Prices.
£			%p.a.	%p.a.				
171,978	Stk.	Feb. 5	5	5	Aldershot 5 p.c. max. C.	78—81	..	..
295,492	,,	,,	4	4	Do. 4 p.c. Pref.	71—76	..	..
1,551,868	,,	Apl. 2	6½	6½	Alliance & Dublin Ord.	65—70	..	..
374,000	,,	Jan. 8	4	4	Do. 4 p.c. Deb.	63—68	..	..
300,000	5	May 7	8	8	Bombay, Ltd.	4⅛—5⅛	..	4⅛—5⅛
170,000	10	Mar. 5	8½	8½	Bournemouth 5 p.c.	12—13	..	..
425,050	10	,,	7	7	Do. B 7 p.c.	12½—12⅝	..	..
150,000	10	,,	6	6	Do. Pref. 6 p.c.	11—12	..	..
50,000	Stk.	Jan. 8	3	3	Do. 3 p.c. Deb.	56—59	..	..
162,025	,,	,,	4	4	Do. 4 p.c. Deb.	78—81	..	..
992,045	,,	Mar. 5	6$\frac{1}{16}$	6$\frac{1}{16}$	Brentford A Con.	95—100	..	..
990,500	,,	,,	6⅛	6⅛	Do. B New	95—100	..	..
76,000	,,	,,	5	5	Do. 5 p.c. Pref.	95—98	..	..
306,690	,,	June 11	4	4	Do. 4 p.c. Deb.	75—80*	−1	79
181,337	,,	,,	6	6	Do. 6 p.c. Rich. Red. Deb.	100—105*	..	..
214,740	,,	Mar. 5	11½	12½	Brighton & Hove Orig.	165—170	..	167—169
244,200	,,	,,	8½	9½	Do. A Ord.	122—125	..	124½
1,287,500	,,	Feb. 19	5	5	Bristol 5 p.c. max.	96½—97½*a*	..	..
855,000	,,	Mar. 19	8	7	British Ord.	110—115	..	..
100,000	,,	Dec. 18	7	7	Do. 7 p.c. Pref.	123—128	..	124—124½
120,000	,,	,,	4	4	Do. 4 p.c. Red. Deb.	72—77	..	..
100,000	10	May 21	6	8	Cape Town, Ltd.	6½—7½	..	7—7⅛
100,000	10	Apl. 23	4½	4½	Do. 4½ p.c. Pref.	6—7	..	..
150,000	Stk.	Dec. 18	4½	4½	Do. 4½ p.c. Deb.	71—76	..	73½—74
626,860	,,	Feb. 19	6	6	Cardiff Con. Ord.	101—104	..	..
237,860	,,	Jan. 8	7½	7½	Do. 7½ p.c. Red. Deb.	104—107	..	..
157,150	,,	Feb. 19	5	6½	Chester 5 p.c. Ord.	89½—94½*b*	..	..
1,513,280	,,	Mar. 5	6	5/14/8	Commercial 4 p.c. Cap.	86—89	..	86
360,000	,,	,,	6	5⅞	Do. 3½ p.c. Cap.	86—89	..	..
475,000	,,	June 11	3	3	Do. 3 p.c. Deb.	56—59*	−1	..
800,000	,,	14 Jan. 15	—	—	Continental Union, Ltd.	35—40	..	..
200,000	,,	June 11	7	7	Do. 7 p.c. Pref.	85—89*	−3	90½
660,000	,,	Mar. 5	6½	6½	Croydon sliding scale	98—102	..	100
284,975	,,	,,	5	5	Do. max. div.	83—86	..	..
492,270	,,	Feb. 19	6	9	Derby Con.	110—112*c*	..	..
55,000	,,	Jan. 8	4	4	Do. Deb.	74—76*c*	..	..
1,002,180	1	Jan. 22	6	4	European, Ltd.	6⅞—7⅛	+⅛	6⅞—7⅛
16,460,070	Stk	Feb. 19	5⅛	5⅛	Gas Light & Coke 4 p.c. Ord.	83—85	..	83⅛—84⅛
2,600,000	,,	,,	3⅛	3⅛	Do. 3½ p.c. max.	62—65	..	*c*2
4,062,235	,,	,,	4	4	Do. 4 p.c. Con. Pref.	78—80	..	79—79⅜
4,761,930	,,	June 11	3	3	Do. 3 p.c. Con. Deb.	58—61*	−1	59½—60⅜
130,000	,,	—	10	10	Do. 10 p.c. Bonds	..	..	..
42,000	,,	—	7½	7½	Do. 7½ p.c. Ilford Deb.	..	..	..
82,500	,,	Mar. 19	6½	6½	Hastings & St. L. 5 p.c. Conv.	92—97	..	..
258,740	,,	,,	5⅜	5⅜	Do. 3½ p.c. Conv.	73—78	..	76½
70,000	10	May 7	10	10	Hongkong & China, Ltd.	17—18	+1½	..
86,600	Stk.	Mar. 5	10	10	Hornsey 7 p.c.	136—141	..	..
1,976,000	,,	May 21	10	59	Imperial Continental Cap.	145—150	−2	146—149
263,950	,,	Feb. 5	3½	3½	Do. 3½ p.c. Red. Deb.	71—74	..	72½—73
235,242	,,	Mar. 19	6½	6½	Lea Bridge 5 p.c. Ord.	96—101	..	..
2,127,340	,,	Feb. 19	5⅛	5⅛	Liverpool 5 p.c. Ord.	87½—88⅛*b*	−1	..
600,000	,,	Mar. 19	7	7	Do. 7 p.c. Red. Pref.	103½—104½*b*	..	104½
165,736	,,	Feb. 19	9	8	Maidstone 5 p.c. Cap.	122—132	..	..
63,480	,,	Dec. 18	3	3	Do. 3 p.c. Deb.	53—58	..	..
75,000	5	Dec. 4	7	5	Malta & Mediterranean	4½—4¾	..	..
541,920	Stk.	June 11	4	4	Montevideo, Ltd.	64—68*	−2	67½
2,061,315	,,	Mar. 5	5	5	Newcastle & Gateshead Con.	75—77*d*	..	..
300,929	,,	,,	4	4	Do. 4 p.c. Pref.	76—77*d*	..	..
529,705	,,	Dec. 18	3½	3½	Do. 3½ p.c. Deb.	68½—69½*d*	..	..
15,000	,,	Mar. 5	11	12	North Middlesex 10 p.c.	..	..	..
75,940	,,	,,	7$\frac{7}{10}$	8$\frac{2}{5}$	Do. 7 p.c.	..	..	..
300,000	Stk.	May 7	9	7	Oriental, Ltd.	100—105	..	104½
188,120	,,	Jan. 8	7⅛	7⅛	Plym'th & Ston'house 5 p.c.	110—115	+1	..
60,000	50	Mar. 5	13	14	Portsea Island B	96—99	..	..
100,000	50	,,	12	13	Do. C	93—98	..	..
2,289,909	1	—	—	—	Primitiva Ord.	9/0—10/0	−/6	9/0—10/0
311,100	100	June 2	4	4	Do. 4 p.c. Red. Deb.	78—80	..	..
600,000	Stk.	Jan. 22	4	4	Do. 4 p.c. Red. Deb. 1911	64—66	..	65—66
220,335	,,	Dec. 18	4	4	Do. B. Aires 4 p.c. Rd. Db.	63—67	..	..
321,670	,,	,,	4	4	Do. R'r P'te 4 p.c. Rd. Db.	63—67	..	..
150,000	10	Mar. 19	6	6	San Paulo 6 p.c. Pref.	7⅛—8⅛	..	..
125,000	50	Jan. 2	5	5	Do. 5 p.c. Red. Deb.	43—46	..	..
270,000	Stk.	Mar. 19	5⅛	5⅛	Sheffield A	103—105*e*	..	..
419,968	,,	,,	5⅛	5⅛	Do. B	103—105*e*	..	..
1,047,000	,,	,,	5⅛	5⅛	Do. C	103—105*e*	..	..
90,000	10	June 11	6	4	South African	7—9*	..	..
5,609,895	Stk.	Feb 19	5	6½	South Met. Ord.	93—95	..	92½—94⅛
2,895,445	,,	Jan. 8	3	3	Do. 3 p.c. Deb.	59—62	..	60⅛
734,000	,,	Mar. 5	6½	6½	Do. 6½ p.c. Red. Deb.	102½—104½	..	103½—103⅝
91,500	,,	Mar. 5	8½	8½	South Shields Con.	135—136*d*	..	..
2,187,795	,,	Feb. 19	6½	6½	South Suburban Ord. 5 p.c.	94—97	−1	94⅛—95
368,837	,,	Dec. 18	5	5	Do. 5 p.c. Deb.	97—100	..	..
647,740	,,	May 7	5	5	South'mpt'n Ord. 5 p.c. max.	80—83	..	81⅛—82
121,375	,,	Dec. 18	4	4	Do. 4 p.c. Deb.	72—77	..	..
250,000	,,	Mar. 5	7	7	Swansea 7 p.c. Red. Pref.	102—104	..	..
200,000	,,	Dec. 18	6½	6½	Do. 6½ p.c. Red. Deb.	103—105	..	..
120,000	,,	Feb. 19	8	8	Tottenham District A 5 p.c.	116—119	..	..
882,275	,,	,,	6½	6½	Do. B 3½ p.c.	93—98	−1	..
150,000	,,	—	—	—	Do. 5½ p.c. Pref.	103—105	..	104—104½
181,255	,,	June 11	4	4	Do. 4 p.c. Deb.	76—79*	−1	77—78⅛
258,251	,,	Mar. 19	5	5	Tynemouth Con. and New Uxbridge, Maidenhead, &	74—76*d*	..	..
197,294	,,	Feb. 19	6⅞	6⅞	Wycombe 5 p.c.	95—100	..	..
88,330	,,	,,	5	5	Do. 5 p.c. pref.	95—100	..	..
91,800	,,	,,	—	6⅞	Do. 5 p.c. Maidenh'd	90—95	..	..
					Wandsworth, Wimbledon, and Epsom—			
50,000	,,	Mar. 5	9½	9½	Wandsworth A 5 p.c.	130—135	..	130
255,636	,,	,,	7⅜	7⅜	Do. B 3½ p.c.	110—115	..	110½—111
392,955	,,	,,	6/9/6	6/9/6	Do. C and New	95—100	..	..
352,000	,,	,,	7⅜	7⅜	Wimbledon 5 p.c.	105—110	..	..
98,000	,,	,,	7⅝	7⅝	Epsom 5 p.c.	112—117	..	..
88,416	,,	Dec. 18	3	3	3 p.c. Deb.	57—60	..	..

Quotations at :—*a*,—Bristol. *b*,—Liverpool. *c*,—Nottingham. *d*,—Newcastle. *e*,—Sheffield. * Ex. div.

Premier Gas Mantles, Ltd., is the title of a Company registered recently, with a capital of £7000 in 4s. ordinary and 1s. deferred shares.

Results at Carlisle.—The annual report of the Carlisle Corporation Gas Committee states that the net profit was £2080. The number of cookers out on March 31 this year was 6309, compared with 5455 on the same date last year—an increase of 854. There has been a marked decline in the prices obtainable over the year for tar, which shows a fall of about 50 p.ct. During nine months of the year under review gas has been sold at 6d. per 1000 c.ft. less than the preceding year; the present price being 3s. 6d. per 1000 c.ft. The extension of the mains to Carleton, Dalston, Burgh-by-Sands, and Kirkandrews has now been completed. The number of additional consumers obtained thereby is very satisfactory.

Manchester Gas Accounts.—The Finance Committee of the Manchester Corporation report, in regard to the gas undertaking, that the approximate account for the past year shows that the result of the working was worse than was anticipated by £5793. The estimates provided for a deficiency of £60,801; actually the figure was £66,594. This difference is occasioned by smaller income than was estimated from the sale of tar and sulphate of ammonia, although the income from sales of gas, hire of fires, &c., and sales of coke is in excess of the estimate. The estimates for the current year provide for a deficiency of £78,929, and in addition it is proposed to meet capital expenditure out of revenue to the extent of £20,000, so that the total amount involved is £98,929. At March 31 next, the accumulated surplus of £32,172 will have been appropriated; and a deficiency of £66,757 will have to be carried forward to be liquidated out of future profits or by increasing the price of gas. The Finance Committee are in conference with the Gas Committee on the matter.

The price of gas at Blairgowrie has been reduced by 6d. per 1000 c.ft., making it 6s. 9d., less 5 p.ct.

Mr. Alan Dawson, a popular member of the clerical staff of the Exeter Gas Company, was drowned while holiday-making near Whitchurch (Salop) last week. He was 22 years of age.

The Burnley Gas Committee, having had a list of employees in the department who were over 60 years of age, have been considering a scheme for the pensioning of aged employees; but for the present further consideration is postponed.

The Lytham St. Annes Gas Department announce that, from April 1 last, the charge for gas to ordinary consumers is 4s. 4½d. per 1000 c.ft., less 4½d. discount, or 4s. per 1000 c.ft. net. Recently the Corporation gave notice of their intention to supply gas of a calorific value of not less than 525 B.Th.U. throughout the borough, in substitution for the present supply of 500 B.Th.U. in the St. Annes area and 430 B.Th.U. in the Lytham area.

NOTICES TO CORRESPONDENTS, ADVERTISERS, AND SUBSCRIBERS.

No notice can be taken of anonymous communications. Whatever is intended for insertion in the "JOURNAL" must be authenticated by the name and address of the writer—not necessarily for publication, but as a proof of good faith.

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Resists 4500° Fahr. Best for Gas-Works.
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THE very best Patent Grids for Holding Oxide Lightly.
See Advertisement, p. 829.

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FOR Gas Works Plant of Every Description; also SULPHATE OF AMMONIA and SULPHUR RECOVERY PLANTS.
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JOHN RILEY & SONS, Limited, Chemical Manufacturers, Hapton, near Burnley, are MAKERS of Special SULPHURIC ACID ("Eagle" Brand), for Sulphate of Ammonia Making. Highest percentage of Sulphate of Ammonia obtained from the use of this Vitriol, which has now been used for upwards of 60 years. Reference given to Gas Companies.

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SATURATORS and all LEAD and TIMBER WORK in connection with Sulphate Plants.
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FOR Motor Lorries and Railway Traffic can be seen erected at our works READY FOR DELIVERY. Inspection by your Engineer invited and a test by your Local Inspector of Weights and Measures before delivery. Every machine a High-Class Engineering Product and fully guaranteed.
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Tins for Sale to Consumers.
In Bulk for Works Use.
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Foleshill Road, COVENTRY.
Telephone: 596. Telegrams: "GASMETER,"
and at 268, Stockport Road, MANCHESTER.
Telephone: RUSHOLME 976. Telegrams: "GASMETER,"
and 46 & 47, Auckland Street, LONDON, S.E. 11.
Telephone: HOP 647. Telegrams: "GASEOUS LAMB."

PATENTS, Trade Marks, Inventions, Advice, Handbook and Consultations free. KING'S PATENT AGENCY LTD., Director B. T. KING, C.I.M.E., Regd. Patent Agent, G.B., U.S., and Can., 146A, QUEEN VICTORIA St., E.C. 4, and 6, QUALITY Ct. (next Pat. Off.), LONDON, W.C. 39 years' refs. 'Phone Cent. 682.

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Address, No. 7551, "GAS JOURNAL," 11, BOLT COURT, FLEET STREET, E.C. 4.

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EXPERIENCED Lecturer and Demon- STRATOR in Cooking by Gas can give Local Demonstrations for Gas Undertakings.
Gas Engineers should apply now for vacant dates to Miss H. H. TUXFORD, M.C.A., "SOUTHBOURNE," BOTTESFORD, NOTTS.

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WANTED — A working Foreman MECHANIC accustomed to all the Repairs and Maintenance Work of a Medium-Size Gas-Works. None but FIRST-Class all-round men need apply. Applicants must be energetic and disciplinarians.
Apply, stating Wage required and enclosing *copies* of Testimonials, to No. 7561, "GAS JOURNAL," 11, BOLT COURT, FLEET STREET, E.C.4.

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(GAS AND WATER DEPARTMENT)

WANTED—a General Clerk for En- gineer and Manager's Office. Experience in the keeping and posting of Accounts essential. Knowledge of Typing and Shorthand desirable.
Applications, stating previous Experience, Age, and Wages required, accompanied by *copies* of Two recent Testimonials, endorsed "GAS-WORKS Clerk," to be addressed to the Chairman of the Gas Committee, Council Offices, Town Hall, New Mills, near Stockport, and Delivered not later than 4 p.m. on Monday next, the 22nd inst.

JOHN S. BROWN,
Engineer and Manager.

Gas and Water Offices,
Gas-Works,
New Mills, near Stockport,
June 13, 1925.

WANTED.—Bricklayers used to Retort Setting, particularly Vertical Retorts. Can start immediately. Standard rates and out money.
WEST'S GAS IMPROVEMENT CO., LTD., MILES PLATTING, MANCHESTER.

PLANT, &c., FOR SALE & WANTED.

GAS PLANT IN STOCK.

PURIFIERS.—Dry lutes. Set of 4— 20 ft. by 14 ft. Sets of 2—10 ft. sq.; and 2—10 ft. by 8 ft; 8 ft. sq. and 10 ft. by 8 ft. water lutes.
Condensers.—Water cooled, 500,000 c.ft. per day. Four Annulars, 36 in. by 18 in. by 16 ft.; 6 in. by 8 in. Pipe Condensers. Also Patent Baffle Plate Condensers.
Livesey Washers.—500,000, and 250,000, and 1t 0,000 per day.
Holmes Rotary Brush Washer.—500,000 c.ft. capacity per day.
Tower Scrubbers.—10 by 70, 4½ by 36, 4½ by 18.
Exhausters.—2000 to 50,000 c.ft. per hour capac.
Station Meters.—3000, 5000, 8000, and 15,000. Also 100 lt. and 200 lt. Meters.
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Gasholder and Steel Tank.—10,000 capacity.
Sulphate of Ammonia Plant (complete).—1 ton per day.

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STEAM-BOILERS For Sale—All Sizes, Vertical. Loco-type, Cornish, Portable, and Other Types of Boilers.
Apply
GRANTHAM BOILER & CRANK CO., LTD., GRANTHAM.

A Quantity New Wire Ropes, Half Price.
THE LONDON ELECTRIC FIRM, CROYDON.

FOR SALE—5000 Tons good second- hand GRANITE SETTS, as they rise, 3 in. by 6 in., 3 in. by 5 in., and some good redressed 4 in. by 5 in. Cheap loaded Rail, Barge, or Lorry.
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FOR SALE— Complete Sets of RETORT BENCH IRONWORK.
BATES AND SONS, WIGSTON LANE, AYLESTONE, LEICESTER.

FOR SALE—About 200 all Copper STREET LANTERNS of various Patterns, complete with China Reflectors, of various Patterns, but mainly 18 in. Hexagon and 16 in. Square, complete with Frogs.
Apply to the SURVEYOR, Town Hall, SALE, CHESHIRE.

GASHOLDER and Steel Tank, 10,000 c.ft. Capacity, with Cup for Telescoping, in good Condition, Cheap.
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FOR Sale—Hornby Gas Analysis Ap- PARATUS with Electric Coil and Oak Tray, in best Working Condition.
Offers should be addressed to No. 7556, "GAS JOURNAL," 11, BOLT COURT, FLEET STREET, E.C. 4.

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CONTRACTS OPEN.

BAKEWELL URBAN DISTRICT COUNCIL.

TENDERS are invited for the Supply of GAS COAL, 2500 Tons, for One Year, delivered at Bakewell Station, L.M. & S. Railway.
Forms of Tender and Particulars can be obtained from the undersigned, to whom Tenders must be sent by June 27.

V. R. COCKERTON,
Clerk to the Council.

Bakewell,
June 12, 1925.

EDINBURGH CORPORATION.
(GAS DEPARTMENT.)

TENDERS FOR TAR.

THE Magistrates and Council are prepared to consider TENDERS for the Purchase of their Coal Gas and Carburetted Water Gas TAR over a period of One, Two, or Three Years at their Option, Delivery of the Tar to be taken in Tank Wagons as produced.
Full Particulars may be obtained from Mr. H. H. Gracie, Engineer and Manager, 15, Calton Hill, Edinburgh.
Sealed Tenders, endorsed "Tender for Gas Tar," to be addressed to the Undersigned on or before Monday, June 22, 1925.
The Magistrates and Council do not bind themselves to accept the lowest or any Offer.

ANDREW GRIERSON, S.S.C.,
Town Clerk.

City Chambers,
Edinburgh,
June 13, 1925.

TENDERS FOR GAS COAL.

THE Gas Committee of the Carnarvon Corporation invite TENDERS for the Supply of 3000 Tons of Best Screened GAS COAL, more or less, to be delivered free as required, in Trucks on the Gas-Works Siding, Carnarvon, during the Twelve Months ending the 1st of July, 1926.
Sealed Tenders, endorsed "Tender for Coal," and addressed to the Chairman of the Gas Committee, Guildhall, Carnarvon, to be Delivered on or before Thursday, June 25.
The Committee reserve to themselves the right to divide the quantity into two or more Contracts, and do not bind themselves to accept the lowest or any Tender.
There is a haulage rate of 5d. per ton from Station to Gas-Works Siding, this to be included in the price quoted per ton.
No special form of Tender issued.

WILLIAM M. RUXTON,
Manager.

Gas Office, Carnarvon,
June 15, 1925.

COMPANY NOTICES.

SOUTH SUBURBAN GAS COMPANY.

NOTICE is Hereby Given that the TRANSFER BOOKS relating to the 5 per cent. Ordinary Stock of this Company WILL BE CLOSED from the 1st to the 28th July proximo, both days inclusive.

By order of the Board.
WILFRID WASTELL,
Secretary.

Head Offices:
Lower Sydenham, S.E 26,
May 30, 1925.

STOCK ISSUES.

By Order of the Directors.

NEW ISSUE OF CAPITAL.

WOLVERHAMPTON GAS COMPANY.

The Directors OFFER FOR SALE BY TENDER not exceeding
£50,000
SIX PER CENT. PREFERENCE STOCK
(Irredeemable).
Minimum Price of Issue, Par.

The Profits of the Company for the Year 1924 were £81,564, and after payment of Interest on the Loan Capital the amount available was sufficient to cover the dividend on the Preference Stock (including the present Issue) more than four times.
Prospectus and Form of Tender (which latter must be received by 11 a.m. on Monday, June 29, 1925) may be obtained from the undersigned.

A. G. WILLIAMS,
Secretary.

Gas Offices,
Darlington Street,
Wolverhampton.

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Specially recommended for use in Gas Works.
We number many leading Gas Companies
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WITH CORRUGATED SECTIONS.

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4 30 ft. by 9 ft. 3 ins.	by 160 lbs.	5752/3 & 5928/9
1 30 ft. by 9 ft. 3 ins.	by 125 lbs.	5974
1 30 ft. by 9 ft. 3 ins.	by 120 lbs.	6027
2 30 ft. by 8 ft. 6 ins.	by 160 lbs.	6127/8
1 30 ft. by 8 ft. 6 ins.	by 120 lbs.	6026
1 30 ft. by 8 ft. 3 ins.	by 120 lbs.	6163
2 30 ft. by 8 ft. 3 ins.	by 100 lbs.	5680/81
4 28 ft. by 7 ft. 6 ins.	by 120 lbs.	5791 & 5782/4
4 28 ft. by 7 ft. 6 ins.	by 160 lbs.	5798/9 & 5756/7

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